STUDIES IN MANAGEMENT OF LESION NEMATODE (*Pratylenchus thornei*) PROBLEM ON CHICKPEA (*Cicer arietinum* L.)

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गुरूर्ब्रह्मा: गुरूर्विष्णु:, गुरूदेव महेश्वरः।

गुरूदेव साक्षात् परब्रह्म, तस्मै श्री गुरूवैः नमः।।

अखण्ड़मण्डलाकारं वयाप्तं येन चराचरम्।

तत्पदंदर्शितं येन तस्मै श्रीगुरूवे नमः।।

CERTIFICATE

This is to certify that the studies conducted by **Mr. Jagdish Kishore** as reported in the present thesis were under my guidance and supervision. The results reported by him are genuine and script of the thesis has been written by the candidate himself. His thesis entitled "**Studies in Management of lesion nematode *(Pratylenchus thornei)* problem on chickpea *(Cicer arietinum* L.)** is therefore being forwarded for the acceptance in fulfillment of the requirement for the degree of Doctor of Philosophy to the university of Allahabad.

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The thesis attached here to, entitled **"Studies in Lesion Nematode (*Pratylenchus thornei)* problem on chickpea *(Cicer arietinum L.)"*** prepared and submitted by **Mr. Jagdish Kishore** in fulfillment of the requirement for the Degree of Doctor of Philosophy in science of Allahabad University is here by accepted.

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Jeeni Sinr

(JAGDISH KISHORE)

CONTENT

LIST OF ABBREVIATION

ai	-	Active ingredient
cm	-	Centimetre
cv	-	Cultivar
d.a.s.	-	Days after sowing
Fig.	-	Figure
g.	-	Gram
ha	-	Hactare
J_2	-	Second stage juvenile
K	-	Potassium
Kg	-	Kilogram
lb	-	Pounds
m^2	-	Metre square
Mm	-	Micrometre
Mg	-	Milligram
ml	-	Millilitre
mm	-	Millimetre
N	-	Nitrogen
ppm	-	Parts per million
P	-	Phosphorous
q	-	Quintal
t	-	Tonne
@	-	At the rate of
"	-	Inch
/	-	Per
>	-	Greater than
<	-	Less than
%	-	Percent
μ	-	Microns

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CHAPTER -1

INTRODUCTION

CHAPTER- I

INTRODUCTION

India is a premier pulse growing country. The pulses are an integral part of the cropping system of the farmers all over the country because these crops well fit in the crop rotation and crop mixtures followed by them. Pulses are important constituents of the Indian diet and supply a major part of the protein requirement. Pulse crops besides being rich in protein and some of the essential amino acids, enrich the soil through symbiotic nitrogen fixation from atmosphere. It is a sad state of affair that the area under them has steadily declined and their total yield has received a serious set back due to several reasons. Plant parasitic nematode are one of the most important agents causing considerable losses to the pulse crops every year.

Gram (*Cicer arietinum* L.) commonly known as chickpea or Bengal gram, Chana (Hindi), Poischiche (French), Kichereb (German), Garbanzo (Spanish), Homos (Arabic), Shinbra (Amharic), occupies a position of pride among the leguminous crop owing to its great importance both as vegetable and pulse. In a country like India where most of the population is primarily vegetarian chickpea has a special place in the daily diet of people due to its high protein content and manifold uses. A large population in this country is already suffering from protein malnutrition due to short supply and high prices of pulses which have gone beyond

the reach of poor man. Therefore, if the over increasing population is to be fed properly in our country, every effort must be made to boost up the production of this important pulse and vegetable crop.

Chickpea belongs to the sub-family Papilionaceae of family Leguminoceae. It is said to be one of the oldest pulses known and cultivated from ancients times both in Asia and Europe. It is grown as a pulse crop throughout tropical and sub-tropical Asia, Northern Africa, Southern Europe, Central America and the Southern United States. It thrives in the cool climate, therefore, it is grown mainly during winter season but severe cold and frost are injurious to it. It is generally grown under rainfed conditions but it gives good returns in irrigated condition as well. It is best suited to areas having moderate rainfall of 60-90 cm per annum. Leguminous pulses in India are being cultivated in 22.5 million hectares with an average of 11.2 million tonnes of production per year. The national average production of pulses at present in 7-9 q/ha (Economic Survey, 1991-92) and in Uttar Pradesh with 13.79 lakh hectares, Madhya Pradesh has first place in acreage and production. The other states of Northern India growing chickpea are Rajasthan (15.32 lakh hectares), Haryana (6.22 lakh hectares), Maharashtra (5.09 lakh hectares), Bihar (1.73 lakh hectares) and Gujarat (1.1 lakh hectares), which is very low in comparison to other countries of the world.

Pulses occupy an important position in agriculture being very good source of vegetable protein (21-44 %) and thus form a prime supplement to cereal based

Indian diet. Considerable emphasis is, therefore, being laid by the Government of India in the matter of increasing pulse production with a view to achieve 35 million tonnes target by the end of 2000 A.D. (The Hindu, 1995).

Chickpea is consumed in different forms. Dry chickpea are used as split chickpea Dal and Besan for various salty and sweet preparation. Both husk and bits of Dal, are valuable cattle feed. Fresh green leaves are used as vegetable (saag). Straw of gram is an excellent fodder for cattle. The grains are also used as vegetable (chhole). It is the leading vegetable among frozen food. Gram is considered to have medicinal effects and it is used for blood purification and tasty leaves due to presence of oxalic acid. It contains 21.1 per cent protein, 61.5 per cent carbohydrate and 4.5 per cent fat. It is also rich in calcium, niacin and iron. Soaked grains and husk are fed to horses and cattle as concentrate and roughage respectively.

The average yield of various pulse crops has remained low in spite of efforts put us by crop improvement scientists at various centres of the country. Losses covered by pests and diseases, including nematodes could also be described as one of the primary reasons for these low yields.

Plant parasitic nematodes are invariably found in the soil around the roots of plants and act as a limiting factor in the crop production by affecting the host plants of their nutrients or causing injury to roots. Nematodes are pests causing significant direct and indirect losses to crop yields. A large number of phytophagous nematodes have been reported from India within the roots and rhizosphere of

various pulse crops. These nematodes have remained neglected and overseen for several years. Though in recent periods *Meloidogyne* spp., *Heterodera* spp. *Hoplolaimus* spp., *Helicotylenchus* spp., *Pratylenchus* spp., *Telotlenchus* spp. and *Rotylenchulus reniformis* have been recognised as potent parasites causing severe damage to respective pulse crops and are held responsible for significant economic losses to their yield.

So far 11 genera and 26 species of phytonematodes including the lesion nematode (*Pratylenchus* spp.) have been reported to be associated with chickpea in India. The root lesion nematode ranks high among the economically important phytonematodes. This nematode species is important due to its ubiquitous distribution, wide host range, migratory endoparasitic nature of parasitism. Rendering the host most vulnerable to secondary attack by other pathogens, due to extensive necrosis and perhaps ability to cause damage even in small numbers (Walia, 1986). All stages of *P. thornei* are reported to undergo anhydrobiosis in a coiled form which enables it to conserve lipid for its survival between respective host crops till 2-8 months. Infectivily of rehydrated *P. thornei* is also reported to be twice that of fresh population. These nematodes can also migrate to a depth of 120 cm in soil as a means of survival during unfavourable condition (Orion *et al.,* 1979; Storcy *et al.,* 1982; Glazer and Orion, 1983; Doyle *et al.,* 1987).

Thirty six species of root lesion nematode – *Pratylenchus* spp. have been reported from India. The important ones from the economic point of view are

P. zeae, P. thornei, P. coffeae and *P. indicus*. The first two species are widely distributed throughout North India and attack several crops with *P. thornei* mainly associated with wheat and gram. It is one of the most important plant parasitic nematode of wheat in Mediterranean region (Lamberti, 1981) especially in Israel (Orion *et al.,* 1982) and chickpea in Syria (Greco *et al.,* 1984) and Italy (Vito *et al.,* 1987). Walia (1982) found its incidence on certain *Rabi* season pulses particularly chickpea in Delhi area. Walia and Seshadri, (1985) reported the pathogenicity of *P. thornei* to chickpea.

Gupta *et al.* (1996) evaluated some oil cakes against *P. thornei* on chickpea. Groundnut, linseed, mustard and *Azadirachta indica* oilseed cakes were evaluated for control of *P. thornei* on chickpea in field trials when mustard, groundnut and linseed cakes were most effective in reducing root population of *P. thornei* at 120 days after sowing and greatest reduction in soil nematode population occurred with groundnut cake, while significant increase in shoot and root mass of chickpea at 90 DAS occurred with mustard and *A. indica* cakes.

In India, few scattered reports on association of root lesion nematode were found with chickpea, but not much work has been carried out on management aspect of this nematode, in spite of being aware of its potential to cause extensive damage to a large number of crops including chickpea. The preliminary survey for root lesion nematode *P. thornei* on chickpea around Allahabad district, revealed their constant association with poor crop growth. In view of above, the present

studies entitled, "Studies in management of lesion nematode (*Pratylenchus. thornei*) problem on chickpea (*Cicer arietinum* L.)" were undertaken to investigate upon the various aspects like, pathogenicity and management of crop damage by chemical and various non-chemical methods, viz. use of oil cakes, mixed cropping, intercropping practices and germplasm resistance. Survey was also undertaken and the seasonal fluctuation in this nematode population was further studied. In view of association of rhizobium with chickpea, effect of various nematode management practices was also evaluated on root nodulation. The results of above studies are presented in this thesis.

CHAPTER -2

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

Species of *Pratylenchus,* popularly known as root lesion nematode due to their characteristic symptoms on roots, are invariably associated with their infection. *Pratylenchus* species are wide in distribution and parasitise a wide variety of field crops. The root lesion nematode rank high among the economically important plant parasitic nematodes. Genera of family Pratylenchidae like, *Pratylenchus, Zygotylenchus, Pratylenchoides* and *Hirschmaniella* have been reported to attack chickpea crop and are considered migratory endo parasites of chickpea roots. Among these genera. *Pratylenchus* is dominent, and its many species have been recorded on chickpea crop.

The genus *Pratylenchus* contains about 64 valid species have been described from different parts of the world. Out of which its 36 species have been reported from India on a number of agricultural crops. In India *Pratylenchus thornei, P. zea, P. mulchandi, P. coffeae, P. indicus, P. brachyrus, P. minyus, P. scribncri, P. pratensis, P. penetrans,* have been reported to associated with chickpea. However, *Pratylenchus thornei* seems to be widely distributed in major chickpea growing areas of the country. *Pratylenchus* spp. has been encountered from Andhra Pradesh, Gujarat, Madhya Pradesh and Utter Pradesh states of India.

DISTRIBUTION:

Pratylenchus thornei, Pratylenchus penetrans and *P. vulnus* have been most frequently noticed on chickpea crop in Mediterranean area. *Pratylenchus thornei* for the first time collected and described by Sher and Allen (1953) from California, U.S.A. Since then it has been reported to occur in Egypt (Oteifa, 1962), Spain (Romero and Arias, 1969), Yugoslavia (Smiljakovie *et al.,* 1974), Cyprus (Philis and Siddiqui, 1976), Jorden (Hashien, 1979), Greece (Koliopanos and Kalyviotis – Gazelas, 1979), Rivoal *et al.,* 1978) and Italy (D Errico, 1970). *Pratylenchus thornei* was also found to associated with pea crops in U.K. (Green and Dennies, 1981) and long fallow disorder of wheat in Australia (Calbran and Meculloch, 1965), Australia, Queensland Department of Primary Industries Annual Report (1981-82). Other reports of its association with crops are from Syria (Greco *et al.,* 1984), Portugal (Abrantes *et al.,* 1987) and Libya (Edongali and Maliah, 1988), *Pratylenchus brachyurus* is considered as serious constraint in the cultivation of chickpea. *Pratylenchus* spp. were reported as very important problem on chickpea in Zimbabwe (Sharma and Donald, 1990). Survey conducted in Algeria, Moracco and Tunisia, demonstrated that root lesion nematodes were present in the nearly all fields sampled during the survey. The large number of *P. mediterraneus, P. penetrans* and *Pratylenchus thornei* extracted from the roots of chickpea and their association with extensive root necrosis indicate that these nematodes are highly damaging to chickpea crop.

Khan and Wadhawa (1969) reported *Pratylenchus thornei* for the first time from Delhi and adjoining areas. Joshi *et al.* (1970) and Sethi and Swarup (1971) reported its association with wheat crops.

Again in (1974), Khan and Singh observed its occurrence in soil from the rhizosphere of a variety of crops in many parts of North India. A population of *Hirchmanniella* spp. was extracted from soil sample from wilted chickpea from Madhya Pradesh (Sobin, *et al.,* 1979). Kaushik and Bajaj (1980), found its wide distribution in Haryana. Sharma *et al.* (1984), results of survey at ICRISAT fields Andhra Pradesh, revealed the heavy population of *Pratylenchus thornei* along with other endo and ecto parasitic nematodes. Where sorghum and various other crops had been grown during the past five years. Anon. (1985), Anver and Alam (1992) survey conducted in Aligarh and Mathura districts of U.P. revealed moderate to high population of *Pratylenchus spp.* along with *Hoplolaimus spp.* and *Tylenchorhyuchus spp.* Anon. (1987) occurrence of *P. thornei* was recorded cent per cent from tehsil Patan of Jabalpur district of M.P. Mishra and Gupta (1988), noticed the incidence of *P. thornei* on sweet pea from Allahabad, U.P. Anon. (1989) later on *P. thornei* was found infesting chickpea crop from Hoshangabad and Jabalpur districts of M.P. Darekar *et al.* (1990) found wide distribution of *P. thornei* in groundnut growing areas of Maharashtra. Ali (1990) concomitant population of *Pratylenchus spp.* (11 %), *Macroposthonia spp.* (8 %), *Sucutellonema spp.* (8 %) and *Heliotylenchus spp.* (100 %) has been reported on chickpea crop in Kanpur

district of Uttar Pradesh. Ali (1991) during winter season, chickpea fields at Indian Institute of Pulses Research (IIPR) experimental and adjoining farm have been reported with infestation of *P. thornei* the frequency of occurrence of *P. thornei* was recorded 14 per cent only with *H. dihystera* (83 %), *Paratylenchus spp.* (14 %) in Kanpur district.

Ali (1992), reported heavy populatien of *P. thornei* (72 %) with *Basirolaimus indus*, Sharma, Ali and Patel *et al.* (1993) reported distribution and importance of plant parasitic nematode associated with pigeonpea in Gujarat state, India.

Ali (1994) survey in five location of Bihar adjoining Nepal revealed the occurrence of *H. oryzae, Hoplalainus spp., M. incognita* and *R. reniformis* while in another survey conducted in Nalanda district of Bihar state, *Pratylenchus spp.* was recorded with *Meloidogyne spp., Heterodra spp., R. reniformis* and *Tylenchohyrnchus spp.*

IDENTIFICATION

Pratylenchus, Zygotylenchus and *Hirschmanniella* belong to family Pratylenchidae while, *Pratylenchoides* belongs to family Radopholinae and many species of these genera are reported on chickpea crop.

Genus Pratylenchus, Filipjev, 1936

Body length under 0.8 mm. No marked sexual dimorphism in anterior region. Lip region flattened anteriorly, continuous or weak, set off, low, lateral

fields each with 4-6 incisors., Deirides absent. Stylet 20 micro um or less long, with round, anteriorly flat or indented basal knobs. Oesophageal glands usually less than two body width long extending over intestine mostly ventrally, vulva in posterior region. Oesophago – Intestinal vulva not well developed posterior female Spermatheca large rounded usually axial. Female tail subcyliondrical to conoid, usually about 2-3 anal body width long, terminus smooth or annolated. Phasmids situated on mid tail or slightly posteriorily. Bursa enclosing tail terminus. Spicules with subterminal pore on dorsal side. Gubernaculum simple through likes and fixed.

Field symptoms :

Infested roots of chickpea by *Pratylenchus thornei* have been reported to exhibit necrotic spots which coalesced and extended to the entire root in case of heavy attack. Their attack on chickpea was evident on above ground and was seldom severe. Damage caused by *P. thornei* is less impressive than that caused by root knot nematodes. The plant shows general stunting, chlorosis and lack of vigour. On roots, infection is characterised by dark brown to black lesion. *Pratylenchus minyus* and *Z. quevarai* have been reported to form large cavities inside chickpea roots in Spain (Al. Cal *et al.,* 1970). A population of 0.1 nematode per cm^3 of soil causes stunting and effects Rhizobium nodulation and more than 8.0 nematodes per cubic centimetre of soil affected germination by 34 per cent, caused 10 per cent seedling mortality of chickpea cv. BG 203 (Walia and Seshadri, 1985;

Sharma *et al.,* 1992). Infested fields by lesion nematodes in Syria showed reduced growth of chickpea and many lesions on root system (Majed Al-ahmad, 1987).

A positive correlation was shown between the number of nematodes in the roots of flowering and the severity of root necrosis (Greco *et al.,* 1992 and Divito *et al.,* 1992). *Pratylenchus thornei* causes severe damage to chickpea when the soil population is more than 0.03 nematodes/cm^2 soil in Syria (Divito *et al.,* 1992). At seedling stage, infestation is manifested by patchy appearance, stunted growth and pale green colour of foliage. Stunting becomes more pronounced as growth advances. The symptoms of attack of *P. thornei* on chickpea roots exhibited as small elongated spot which turned to brown in sandy soils of Gwalior district, M.P. (Ali, 1993).

Host range :

Population of *P. thornei* have been reported to develop better from fall to early spring in Mediterranean region. Winfield (1964), Lucas (1965) and Williams (1969) found *P. thornei* infesting tobacco, sugarcane and roses, respectively. A glass house study conducted by Orion (1974) showed that *P. thornei* reproduced on potato, wheat and red clover. It was one of the frequently encountered nematodes on *Phaseolus vulgaris* in Southern Italy (Vaylas and Inserra, 1977 and Inserr *et al.,* 1979). O'Brien (1982, 1983) in a pot experiment, proved its capability to reproduce well on navy bean, sorghum, maize, soybean and clipper barley. Storey (1982) used *Vicia sativa* for multiplying and maintaining culture of *P. thornei.* Feba bean (*Vicia*

faba L.), lentil (*Lens culinaris*) and alfalfa (*Medicaga sativa* L.) were reported to be good hosts of this nematodes (Greco *et al.,* 1984). Greco *et al.* (1988) reported moderate infestations with *P. thornei* on lettuce, potato, cauliflower and cereals and low on carrot, radish, coriander, spinach and sugarbeet. Almond was found to be infected with these nematode in eastern region of Libya (Edongali and Malish, 1988).

Pratylenchus thornei has been reported to be associated with wheat in India (Joshi *et al.,* 1970). Kaushik and Bajaj (1980) found *P. thornei* infesting mung in Haryana. *P. thornei* population decreased on green gram and increased on maize and chickpea (Walia, 1982), *P. thornei* reproduced well on chickpea and leguminous plant species. Chickpea was reported as fair host for *P. coffea* (Das and Das, 1985). Mishra and Gupta (1988) noticed that sweet pea was a good host of *P. thornei* while it was reported non host for *P. zeac* (Hashmi and Hashmi, 1989). Lesion nematodes are adopted to a large variety of environmental conditions and have large no. of hosts (Greco and Sharma, 1990) wheat, barley maize and sorghum reported as good hosts for *P. thornei* infestation was reported on lentil, pea, mungbean, urdbean, frenchbean, fababean, idzukibean, pigeonpea and cowpea from Kanpur district, India (Ali, 1991).

Price (1994) in Cameroon, West Africa, 25 musa types were grown at an altitude of 950 m in land infested with *Pratylenchus goodey,* during 1992. Root sampling showed that most plantain (Musa) and the 2 AAB types Pisang Jari Buay

(AA) was also susceptible. Both *M. acuminata* and *M. balbisiona* showed low susceptibility as did the cooking banana. Banana coction (AAA) of the lugugira group.

Pathogenecity :

Chickpea plants when subjected to infection level of 104 *Pratylenchus thornei,* plant developed paler in about 4 weeks with a tendency to be come yellow. The opposite leaves showed tendency to remain together during noon becoming normal at day break. Inoculated plants had significantly reduced height. They also exhibited delayed flowering, the buds usually aborted and fell. The following review covers root lesion nematodes in general, with emphasis on *P. thornei.*

Ofeifa (1962) from U.A.R. reported *P. zeae* to be an important limiting factor in production of a number of important crops including cowpea and broad bean. They observed that this nematodes was associated with crop decline, even though soil moisture was adequate and good management practices were followed.

Torte (1971) observed that there was a significant negative correlation between the initial population of *P. zeac* and dry weight of aerial parts of corn. Winfield (1974) reported that *P. vulnus* and *P. thornei* even in small numbers can cause decline in roses.

In glass house experiments, Recucnco (1975) studied the pathogenecity of root lesion nematode (*Pratylenchus spp.*) on sugarcane. Seedlings grown in pots inoculated with 100, 500, 1000 adults of *Pratylenchus spp.* showed significant

reduction in the green top weight, cane weight, number of internodes, thickness of basal internodes and length of longer cane at all the inoculum levels after 130 days, although other parts and root weight were not significantly affected.

Thompson *et al.* (1976) carried out pathogenicity tests with *P. scribeneri* against snapbean and limabean. The nematodes population increased nearly 75 fold on susceptible snapbean *Phaseolus vulgaris* and reduced its top growth but reproduced slowly and did not affect top growth of resistant limabean *P. lunatus.* Ellioff *et al.* (1980) evaluated the effect of initial population densities of *Pratylenchus penetrans* (0, 25, 150 and 300/100 cm^3 soil) on growth and yield of dry beans (*Phaseolus vulgaris*) cv. Sanilac grown viz. soil types (Sandy loam, sandy clay loam and clay loam) at moisture levels corresponding to matric potentials of –0.05, 0.05 and –10 bar, root weight, plant height, shoot dry weight and yield of dry beans were significantly reduced by densities of 150 and 300 *P. penetrans* in all soil types and at all moisture levels. With 300 *P. penetrans* per 100 cm^2 soil, bean yields decreased by 78, 72 and 86 per cent in the sandy loam, clay loam and sandy clay loam respectively at a metric potential of –10 bar. Walia's (1982) studies on the root lesion nematodes *Pratylenchus spp.* infesting some pulse crops. Willis *et al.* (1982) investigated infectivity of *Pratylenchus crenatus* and *P. penetrans* on forage legumes and grasses and effect on forage yield both in glass house and field experiments in Canada. *P. crenatus* did not affect the forage yield of lucerne, birds foot trefoil, red clover, bromegrass, orchard grass and timothy, but *P.*

penetrans reduced yields of birds foot trefoil, red clover and lucorne in descending order. Azmi (1984) reported that the length and dry weight of shoot and root of *Leucaena leucoephala* decreased as the inoculum density of *Pratylenchus zeae* increased from 0-10,000 nematodes/500 ml soil.

Edward *et al.* (1970) observed patches of poorly growing gram crop at Allahabad, India and found it to be associated with high population of *P. zeae*. The grains formed in such plants had shrunken appearance.

Van Gundy *et al.* (1974) reported that *Pratylenchus thornei* infected wheat plant showed reduced tillering and reduced size and number of ears.

Mahapatra and Das (1979) studied host range and pathogenicity of *Tyleonchorhynchus* on maize (*Zea mays*).

Orion *et al.* (1979) studied the pathogenicity of *Pratylenchus thornei* on lucerne, barley, potatoes, clover, watermelon and wheat and showed reduction in shoot and root weights of all the above mentioned plants.

Walia and Seshadri (1985) studied pathogenicity of the root lesion nematode *P. thornei* on chickpea. Inoculation of chickpea at 500 and 1000 *P. thornei* was reported to reduced plant growth significantly.

Mahapatra and Dadhi (1986) conducted pathogenicity and control trials with of *Rotylenchulus reniformis* on *Cicer arietinum.*

Ahmed *et al.* (1987) conducted pathogenicity trials with reniform nematodes, *Rotylenchulus reniformis* on chickpea.

Greco, Divito, Saxena, Reddy (1988) did investigation on the root lesion nematode *Pratylenchus thornei.*

Majtahedi *et al.* (1988) reported that *P. thornei* infected dry land winter wheat plants in Washington state, U.S.A. were stunted and chlorotic, in a pot experiment with 400 and 4000 nematode pot, inoculum level of 4000 significantly reduced fresh top weight (24+7 %) and dry weight (48+5 %) of wheat.

Bhatti and Bhatti (1989) studied pathogenicity of root-knot nematode (*Meloidogyne javanica*) on chickpea (*Cicer arietinum*). Bhatt (1992) studied pathogenic effect of *Pratylenchus thornei* (Filipljev, 1936). Sher and Allen (1953) studied the yield and protein content in gram (*Cicer arietinum* L.). They reported that inoculated plants had lower nitrogen content and total protein. *P. thornei* inoculated seedlings of chickpea (VK 850) exhibited significant reduction in growth. At an initial density of 500 or more nematode per kg of soil (Tyagi and Parveen, 1992). *P. thornei* was reported to cause extensive damage of roots, alter host physiology and nutrient deficiency to chickpea plant. Inoculation of chickpea with *P. thornei* at 10, 100, 1000, 10000 nematodes per plant showed that there was a significant reduction in growth characters at and above 100 nematodes kg^{-1} soil.

Sebastian and Gupta (1993) studied the rate of nematodes multiplication as judged by total population per root system and reported that it was found to be

inversely proportional to the initial inoculum level of nematode. With initial inoculum level of 500 and 1000 nematodes, the final population was recorded 3.7 and 2.6 times, respectively.

Effect on nodulation :

Hussely and Barker (1974) studied the effect of nematodes with different feeding habits on the nodulation of legumes and said that *Pratylenchus penetrans* had little effect on nodulation in soybean peanut and cowpea, but damaged nodules of garden pea.

Basigalup *et al.* (1988) reported the effect of *Pratylenchus penetrans* on nodulation and N_2 fixation in alfalfa clones. Using free choice (FC) and no choice (NC) tests 25 lucerne clones differing in resistance to *P. penetrans* were assessed after 6 weeks following inoculation with 100 and 200 nematodes/plant respectively for nodule number and size plus nitrogenous activity. *P. penetrans* reduced nodule number in both the (FE) and (NC) tests, but nodule size was not affected. Nitrogenase activity was significantly reduced in susceptible clones in the (NC) test.

NEMATODE MANAGEMENT

Cultural

Crop rotation

Hiede (1975) studied migratory root nematodes as pests of cereals in crop rotation. Under intensive cereal cultivations migratory plant parasitic nematodes,

especially *Pratylenchus,* are increasing in importance in German Democratic Republic (GDR). The author reviews the relevant literature on the pathogenicity of *P. neglectus, P. crenatus, P. thornei* and the effects of crop rotation and concentration of nematode population dynamics. The present situation is assessed and migratory root feeding nematodes are considered to be a potential danger. The need is indicated for research on the effects on population dynamics of crop rotation, growth factors and ecological factors.

Heide (1975) studied the effect of nematode population of 4 years in cereals monoculture (barley, rye, wheat and oats) and Chernozem soil was compared with that when the cereal species were grown in alternate years and in some cases, substituted by peas or field beans. *Pratylenchus* was represented by pure *P. neglectus* population. Considerable variations in population numbers with in and between the different years were typical of *P. neglectus,* the population rarely exceeding 200 to 300 nematodes/100 cm^3 of soil. Only winter rye depressed nematode multiplication and root infestation while no appreciable difference was observed with the other crops, either in monoculture or rotation. *P. neglectus* soil infestation did not affect crop yields. Population of *Tylenchorhynchus* and *Tylenchus* were unaffected by the crops studied. *Rotylenchus* numbers were reduced under oats. The inclusion of winter rye, peas and fields beans in rotations of combine harvested crops is considered beneficial in suppressing *Pratylenchus* populations.

Greco and Divito (1987) reported rotation programme to suppress nematodes population is an alternative to limit the yield loss.

Greco and Sharma (1990) studied the several nematode species have been reported to be associated with chickpea. A few of these cause severe damage to this pulse crop. *Meloidogyne arenaria, M. incognita* and *M. javanica* infect chickpea in the Indian sub-continent and *M. artiellia* is noxious in the Mediterranean basin. *Heterodera ciceri* causes yield reduction in northern Syria. *Pratylenchus thornei* and *Pratylenchus spp.* and *Rotylenchulus reniformis* have also been reported to reduce yield in chickpea. Nematodes cause root vascular and parenchyma disorders, suppress rhizobium nodulation and interact with several soil borne fungi.

Infested plants suffer drought stress, earlier sense and yield poorly, crop rotation can provide good control of *H. coceri* and *M. artiellia* because of their rather narrow host ranges, but not of the other *Meloidoglyne species, Pratylenchus spp.* and *R. reniformis,* which are polyphagous. A suitable chickpea cultivar with resistance to nematodes is not available. Therefore, investigations are required to enable development of crop management strategies that can be utilized to maintain nematode population below threshold levels.

Ambrogioni; Caroppo and Marinari (1990) studied the effects of the following cropping pattern monocultures of hard wheat and hard wheat intercropped with soybean and biennial rotation of sugarbeet-wheat, sorghum-wheat and sunflower, wheat. Nematode extraction from soil samples showed *Pratylenchus*

neglectus and to a lesser extent. *P. penetrans* to be the most numerous, their numbers always increasing after a wheat crop, as did those of *Pratylenchus spp.*, *Pratylenchoides ritteri* were most numerous after wheat intercropped with soybean and merlinives spp. after the mono cultures and the sunflower wheat rotation. The endo parasites *Pratylenchus spp.* was found chiefly in wheat, soybean and sunflower roots. While *Pratylenchoides spp.* were mainly in wheat and soybean of the ecto parasites, *Pratylenchus* were associated mainly with soybean and merlinive with soybean and wheat. This synthesis of a 4 year report (1985-86 and 1988-89) appeared in the proceedings of the special project on cropping system.

Vito-m-di; Greco; Di-vito (1994), the most common methods of controlling the most important nematodes of legumes are discussed. These includes crop rotation where 3-4 year rotations could provide sufficient control of *Heterodera goettingiana* and *Heterodera ciceri* and to a lesser extent also or *Meloidogyne articlia.* Soil solarization which has shown promise in controlling *Pratylenchus thornei* and *Heterodera ciceri* on chickpea and has also been reported to be effective against *Meloidogyne spp.* Chemical control using fumigants and non-volatile nematicides and resistant cultivars which is so for of limited important due to the very limited number of those with good agronomic characteristics.

MIXED CROPPING:

Prasad and Rao (1979) studied the effect of mixed cropping using mungbean (*Phaseolus spp.*) and groundnut (*Arachis hypogea*) with rice (*Oryzae sativa*) and

ragi (*Eleusine coracana*) on population of *Pratylenchus indicus, Hoplolaiomus indicus, Tylenchorhychus spp.* and *Helicotylenchus spp.*

INTERCROPPING :

Naganathan, Arumugam, Kulase Karan, Vadivelu (1988), studied population of *Radopholus similis* and *Pratylenchus coffeae* on banana roots and reported that they were significantly reduced by growing antagonistic crops viz. Tagetes, Lucerne, sunhemp (*Crotalaria juncea*) or coriander (*Coriandrum sativum*) as intercrops for 4 months.

Abd-Elgawad, Saad (1989) studied the effect of intercropping of *Phaseolus vulgaris* on the population cynamics of *Tylenchorhynchus clarus* and *Pratylenchus spp.* was investigated in the field in Egypt. Higher population of both nematodes occurred when *P. vulgaris* was intercropped with maize than when grown in pure stand but differences were not statistically significant. Sex ratios indicated more female *T. clarus* on intercropped bean while *T. clarus* Juvanils always out numbered adults during the growing season. The effect of different ammonium fertilizers on the final nematode population was also investigated.

Atu (1991) reported to Pucraria phasialoids, yam intercropped with cowpea, Cassava intercropped with maize and fallow vegetation (mainly panicum maximum) were grown in a reclaimed gully site. Initial soil sample showed the presence of *Meloidogyne incognita, Scutellonema bradys* and *Pratylenchus brachyurus.* Composite random soil samples collected from the rhizophere at

monthly intervals and nematodes extraction from roots at harvest showed that *Meloidogyne incognita* and *S. bradys* population significantly increased in yam intercropped with cowpea and pueraria plots. While *P. brachyurus* was highest in the fallow and cassava intercropped with maize plots.

Supratoyo (1993) in an experiment to study the effect of *Tagetes erecta* and *T. patula* in controlling plant parasitic nematodes on banana was conducted at the banana collection garden, Agricultural Extension Service for food crops, Yogyakarta banana variety used in this experiment was "Pisang Roja" and the plant was intercropped with both tagetes plants. Banana was intercropped with 6 rows each of *T. erecta* and *T. patula* and banana with no intercropping. Observations were done on the number of plant parasitic nematodes in the soil on each plot before planting, population numbers in the soil and banana roots on each plot at 30, 60, 90 and 120 days after planting and the growth periods of both *T. erecta* and *T. patula. T. erecta* and *T. patula* were able to suppress the population of *Meloidogyne, Radopholus* and *Pratylenchus* and were able to reduce banana root damage. There is no difference between the *T. erecta* and *T. Patula* ability in suppressing plant parasitic nematodes in banana. The vegetative stage of *T. erecta* however, was longer than *T. patula.* Therefore its effective age for controlling plant parasitic nematode on banana was also longer than *T. patula.*

Gnanapragasam (1997) a list of plant species having nematicidal properties against *Pratylenchus loosi, Radopholus similis,* attacking tea in Sri Lanka is given.

The use of various oil cakes and plant extracts on intercropping with *Eragrostis curvula, Vetivera zizanoides, Tagetes spp. Calliandra calothyrsus* and *Cassia spectabilis* is suggested.

CHEMICAL

Heide; Palm (1972) studies in pot experiments that at 10 ml/m^2 methan sodium (vapam) gave good control of migratory and root-knot nematodes; 20 ml/m^2 gave results comparable to 50 gm/m^2 dazomet, work continues.

Heide (1973) in pot and glass house experiments on a humus and sandy soil, tested Nematin (vapam) and Basamid and reported that control they root knot nematodes and migratory root nematodes at doses considerably less than the recommended rates. 20 g/m^2 Basmid and 50 ml/m^2 Nematin showed an initial effect on the soil population of *Meloidogyne* corresponding to the approved application rates. The effect on the soil population, at 50 ml/m^2 was only slightly less. In the first crop after nematicide application, the formation of root knots on lettuce was reduced by 99 % with the 150 ml/m^2 Nematin, by 48 % with 50 ml/m^2 and by 83 % with 20 g/m^2 Basamid. Even at 150 ml/m^2 Nematin, complete control was not possible. The resowing on the treated areas was as heavily infested as the control. In pot experiments 20 ml/m^2 Nematin was effective against *Pratylenchus penetrans* and *P. neglectus* at the approved application rates, as was 50 ml/m^2 Nematin and 20 ml/m^2 Basamid against *Rotylenchus spp.* in glass house tests.

Heide (1974) in pot and green house experiments with lettuces and tomatoes with Nematin (Vapam) at 10, 15, 20, 100, 150 or 200 ml/m^2 or Basamid (dazomet) at 20 or 50 ml/m^2 were used to control *Meloidogyne spp.* Even the generally accepted doses of 150 ml Nematin and 50 g Basamid did not completely destroy the soil population of nematodes with the result than when one subsequent host crop had been grown without nematicidal treatment the population again reached the levels of untreated control. However, reduced amounts of nematicides may be applied as prophylactic measure in cases of minor infestation e.g. at the beginning of population build up. On the humus or sandy soil used in these tests, 50-75 ml nematin/m^2 20 g Basamid/m^2 were sufficient for this purpose.

Magnifico, Vovlas (1975) observed ~~of~~ Good weed control with 7.5 g/ha chlorthal-dimethyl, 0.89 trifluralin, 1.92 g dibutalin or 3.5 g nitrofen, methan-sodium dazomet and potassium azide at 100, 392 and 10 g/ha, respectively to be effective against grasses. Infestations of *Pratylenchus thornei* and *Pratylenchus neoamblycephalus* were significantly reduced by pre-sowing application of dazomet and fenamiphos at 392 and 50 g/ha respectively.

Philis (1976) carried out the Nematicide trials ~~were at~~ 2 localities in Cyprus for the control of nematodes (*Pratylenchus neoamblycephalus, Heterodera carotae* and *Pratylenchus thornei* on carrots). The nematicides D-D, DBCP, Di-trapex, fensulphothion, phenamiphos, prophos, Neosar and oxamyl applied before sowing controlled the nematode and increased marketable yields. Dazomet at 330.7 kg/ha

was phytotoxic in the first year and in the second year yields were considerably increased but nematode damage was more pronounced on lighter than on heavier soil.

Nair (1979) In Trichur, India, applied fensulfothion, aldicarb, carbofuran, phorate and phenamiphos at 2 g ai/plant and Neem cake at 400 g ai./plant to banana, var. Nendran at planting and after 4 months. Soil and root samples taken at months 4 and 8 after planting indicated that all treatments significantly reduced numbers of *Radopholus similis, Pratylenchus spp., Helicotylenchus spp.* and total numbers of nematodes. Bunch weight were increased. Phenamiphos and aldicarb were the most effective treatment.

Eissa (1982) observed in field trials at Riyath, Saudi Arabia, Tuber yields of potato cv. Merika increased from 1.45 t/ha with no nematodes control to 1.66, 1.74 and 1.97 t/ha with application of oxamyl, carbofuran and phenamiphos (fenamiphus), respectively in 1978. Yields were low due to late planting. In 1979 corresponding tuber yields of cv. Ajax were 14.17, 16.70, 16.89 and 16.04 t/ha. Fensul-fo-thion and nemamost (DCIP) reduced yield in both years. Similar results were achieved with cv. Marika in 1980. Application of phenamiphos, aldicarb and carbofuran at 25.5 and 12.5 kg ai./ha respectively to potato cvs. Merika and Ajax in field experiments gave best tuber yield and best control of *P. thornei.*

Eissa; Moussa (1982) applied aldicarb, corbufuran or phenomiphos to clay loam fields of wheat cvs. Chnap and Giza 157 in Egypt, controlled *Pratylenchus*

thornei, Tylenchorhynchus clarus and *Criconemoides ornatus* and increased grain yield up to 36 % and straw yield up to 20 per cent compared to untreated controls. A nematistatic value (NSTC) is suggested for comparing treatment, depending on the population characteristic of each nematode species. NSTC = RR treatments. RR check x 10; RR (rate or reproduction) = Pf+1/Pi; Pi = initial population, Pf = final population. Best treatments give lowest NSTC values.

In field trials at Kafr El-Khadraa, grain yield of wheat cv. Chnap (Chenab) and Giza 157 increased from 2.20 and 1.89 tonnes/feddan with no nematode control to 2.67, 2.82 and 2.99 and 2.39, 2.29 and 2.54 tonnes with application of carbofuran, phenamiphos (fenamiphos) and aldicarb respectively. Straw yield were also increased by nematode control (1 feddan = 0.42 ha).

Walia, Seshadri (1985) reported that the application of aldicarb, carbofuran, fensulfothion or phorate at 3 doses (1 to 2 % seed weight) each to *Cicer arietinum* through seed treatment significantly reduced final population of *P. thornei* the highest doses given nematode degradation.

Soil application of aldicarb reduced the population of *Pratylenchus thornei* and root necrosis in chickpea (ICARDA, 1985 b). However, some phytotoxicity was observed on chickpea when 190 kg a.i., aldicarb was applied/ha. Application of 10 kg a.i. aldicarb/ha in two or three splits reduced the phytotoxicity (ICARDA, 1986). Soil treatment with aldicarb at 5-10 kg a.i./ha greatly suppressed

1986). Soil treatment with aldicarb at 5-10 kg a.i./ha greatly suppressed *Pratylenchus thornei* root invasion and increased chickpea yield but the seed treatment were ineffective (Greco *et al.*, 1988).

Schotle (1989) studied the effect of *Streptomyces spp.* on the growth of potato in 3 pot experiments, in two of which the effect of *V. dahliae* was assessed. *Streptomyces spp.* attacked all underground plant parts of susceptible potato cultivars early in the growing season, the roots were seriously attacked, markedly reducing tuber yield and number but prolonging the duration of the growing season. The nematicide oxamyl had little effect on the incidence of netted scab. Repeated growing of the susceptible cultivar Binje greatly increased soil contamination with *Streptomyces spp. V. dahliae* reduced growth before wilt symptoms were evident and it reduced tuber yield but not number. Oxamyle delayed infection by *V. dahliae* by controlling *Pratylenchus spp.* (mainly *Pratylenchus thornei).*

Thompson (1990) tried partial sterilization methods to eliminate *P. thornei* from a vertisal air dried soil, with nematodes apparently in a state of an hydrobiosis, was treated with gamma irradition (5, 7.5, 10 or 20 kc), aerated steam (50, 60, 70 or 80xc for 30 minutes) or methyl bromide fumigation and motile nematodes were extracted in white head trays. Approximately 1 per cent of *P. thornei* survived 5 kg of gamma irradiation but none survived 7.5 kg or more. Approximately 50 and 10 per cent survived 50 and 60xc aerated steam treatment, respectively, but none survived 70 or 80xc or methyl bromide fumigation. *P. thornei* was more tolerant of

partial sterilization treatment than were saprobiotic nematodes present in the same soil. Davito *et al.* (1991) reported that the population of *P. thornei* were greatly reduced in plots treated with aldicarb @ 10 kg oil/ha, 5 kg ai./ha under crop row at sowing and the 5 kg a.i./ha at standing crop after emergence of the chickpea cv. Ghab-I .The control of nematodes by aldicarb treatments enhanced the grain yield of chickpea by two to three times compared to untreated control.

Sebastian and Gupta (1993) studied the effect of soil application of carbofuran, marshall and phorate @ 0.2 g ai./m^2 and reported increased shoot length at 30, 60 and 90 days after sowing and shoot and root at 90 days compared to control (1000 nematodes per plant) plants. The nematicides also reduced the population of *Pratylenchus thornei* per root system as well as per gram of chickpea root. Phorate .and carbofuran were equally effective against *P. thornei* while marshall though reduced the nematode population but not to the same degree as other two chemicals.

Ramakrishan, Vadivelu (1995) observation of field experiments showed that carbofuran 3 g at 0.75 ai./ha applied 20 days after planting chrysanthemum was the most effect in controlling *Pratylenchus penetrans, Meloidogyne incognita, Rotylenchulus reniformis* and *Helicotylenchus sp.* and increased flower yield by 55 per cent over the untreated control treatment with quinalphos.

ORGANIC AMENDMENTS :

Control of plant diseases with organic amendments in the form of oil cakes, green manures, crop residues, food bases and other products have extensively been reviewed (Garrett, 1956 and 1965; Patric, 1965; Papavizas, 1966 and 1973 and Cook *et al.,* 1978). The control of phytoparasitic nematodes by the application of organic matter to the soil may be attributed to several factors (Sitaramaih and Singh, 1978; Duddington *et al.,* 1960 and 1961) viz. the organic matter may be directly toxic to nematode, it may produce substance toxic to the pathogen during its decomposition, it may increases the soil population of predacious fungi or nematodes which ultimately bring down the population of plant parasitic nematodes. Besides, these organic amendments after the soil texture and structure, increase the water holding capacity of soil which may favour the plant growth. They also provide additional plant nutrients.

Not much work has been carried out in the use of organic amendments for the management of lesion nematodes *Pratylenchus spp.* Therefore, a concised available review of literature related to work done in this study has been cited.

Khan *et al.* (1974) reported that ammonia liberated during decomposition of oil cakes (Mahua, castor, mustard, Neem and groundnut) was toxic to varying degrees to several species of plant parasitic nematodes, Alam and Khan (1974) reported greatest reduction in the population of stylet bearing nematodes with Neem cake and nemagon followed by Mahua cake. DD, mustard cake, groundnut cake and

castor cake. They further suggested that Neem oil cake reduced the population of parasitic nematodes 32-35 per cent and other oil cakes were almost as effective as DD and nemagon.

Siddiqui *et al.* (1976) observation of amended soil with oil cakes of Neem, groundnut, mustard and castor suggest that they reduced the population of *Tylenchorhynchus brassicae* around the roots of cabbage and cauliflower. Amendments also significantly ameliorated the condition of crops as compared to inorganic fertilizers. In the absence of host, the fall in the population of nematodes was higher in oil cake amended soils than in soils treated with inorganic fertilizers.

Siddiqui *et al.* (1976a) studied the effects of treatments with oil cakes of Neem, groundnut, mustard, castor or Mahua on nematode population and yield of several vegetable. In general oil cake amendments reduced population of *Hoplolaimus indicus, Tylenchorhynchus brassicae, Helicotylenchus spp.* and *Meloidogyne incognita.* They further reported that mustard cake on tomato, carrot and potato, groundnut cake on sugarbeet and radish, castor cake on turnip were more effective. Mustard cake gave the highest plant yields while Mahua cake adversely affected yields of all crops.

Zaiyd (1977) found in *Meloidogyne javanica* inoculated pots, gall number was reduced and plant top weight increased by the addition of mustard, groundnut, linseed and castor cakes to okra plants.

Saxena *et al.* (1977) observed that mustard oil cakes (500 kg/ha) and margosa (*Azadirachta indica)* leaves (300 kg/ha) were effective in controlling *Tylenchorhynchus spp., Helicotylenchus spp.* and *Meloidogyne spp.* on grape vine at Ludhiana, India.

Sitaramaih and Singh (1978) evaluated the effect of soil application of margosa cake or mixed wood sawdust from *Shorca robusta* and *Dalbergia sisoo* plus NPK on phenolic contents of soil and in tomato roots and on root invasion by larvae of *Meloidogyne javanica* on tomato. They reported that phenolic contents of the amended soil increased in relation to the quantity of amendments added. The length of the decomposition period and that there were more phenols in the soil amended with morgosa cake than in the sawdust amended soil and more in tomato roots grown in amended soil than in the non amended soil. Significantly fewer larvae of *Meloidogyne javanica* invaded tomato roots exposed to phenols than the untreated ones.

Alam *et al.* (1978) reported that in Mahua, castor, mustard, Neem and groundnut cakes, formaldehyde concentration was 0.966, 0.088, 0.316, 0.258, 0.465 and acetone 0.900, 0.110, 0.220, 0.280, 0.180 mg/100 mg samples. Mortality of 5 nematode species in 1000 ppm formaldehyde was 100 per cent per 12 hours but in acetone, the mortality varied from 2 to 41 per cent even at 10,000 ppm, larval hatch of *Meloidogyne ioncognita* decreased with increasing formaldehyde concentration and acetone did not affect hatch.

Alam *et al.* (1979, publ. 1980) detected considerable amount of phenols in the oil cakes of Mahua, castor, mustard, Neem, groundnut, with highest concentration in mustard cake. Their studies on the effect of ten phenolic and related compounds on the mortality and population of nematodes showed that all the tested were highly deleterious to *Hoplolaimus indicus, Helicotylenchus indicus, Rotylenchulus reniformis, Tylenchorhynchus brassicae* and *Tylenchus filoformis,* with hydroquinone peresol, catecnol, pyrogallol and gallic acid being most toxic compounds.

Kaliram and Gupta (1980) studied the efficacy of fresh Neem leaf extract in the control of *Meloidogyne javanica* infecting chickpea. Aqueous extracts from 10, 20, 30 or 40 g Neem leaves/kg of treated soil were applied to young chickpea plants grown in *Meloidogyne javanica* infested soil.

Plant growth (shoot and root lengths, fresh shoot and root weights) was greatest and root galling least with highest application rate, with effects decreasing with a reduction of application rate. Patel *et al.* (1985) compared the efficacy of azolla and mustard cake at 3 per cent soil weight basis for the management of root knot nematode (*Meloidogyne javanica* and *Meloidogyne incognita*) on okra, maximum plant growth with minimum root knot index was obtained with dry azolla followed by mustard cake.

Jain and Husan (1986) studied in the field experiment that application of Neem cake increased the fodder production, and seed yield of oats and cowpea.

They also observed a maximum increase in the photosynthetic pigments of oat leaves and considerably reduced total nematode population under oat and succeeding cowpea crop.

Alam and Ashraf (1986) studied the influence of organic soil amendments and nematicides on plant parasitic nematodes infecting *Triticale hexaploide*. Compost, bone meal, oilseed cakes of castor, mustard, margosa/Neem and peanut, DD, DBCP, phorate, fensalphothion and dimethoate were applied to wheat for the control of plant parasitic nematodes. Inorganic fertilizers and compost did not suppress the population of plant parasitic nematodes significantly, while all other soil amendment and nematicides significantly reduced nematode population.

Sunderaraju and Koshy (1986) reported that Neem oil cake (1.5 kg/palm) significantly reduced the nematode population of *Radopholus similis* on arecanut palm compared with control.

Singh *et al.* (1988) conducted a pot experiment where aubergine seedlings were grown in soil heavily infested with *Meloidogyne spp.* and then treated with castor (*Ricinus communis*), mustard, Neem (*Azadirachta indica*), Mahua (*Madhuca longifolia*) or groundnut (*Arachis hypogia*) oil cakes alone or in combination. All oil cake treatments were reported to reduce the nematode population.

Schauer, Blume (1988) investigated the effect of de-oiled, crushed seed of Neem (*Azadirachta indica*) and residues of meo H/m TB seed kernel extraction (AZT-residue) on *Pratylenchus penetrans*. Both extraction residues were applied in

concentration between 500 and 4170 mg/kg as soil amendments in pot trials. All Neem amendments resulted in a marked reduction in numbers of *P. penetrans* in roots of winter wheat. In the oil cake and AZT residue application, the nematode population was reduced to 7 and 20 per cent of the control respectively. The wheat plant grew better when Neem was applied.

Sen and Gupta (1989) ~~observation~~ used three organic amendments sawdust, Neem leaves and Neem oil cakes at 25 g/ha for the control of root knot nematodes *Meloidogyne spp.* on tomato, okra and aubergine. Best nematode control was obtained with Neem cake followed by sawdust,Neem leaves.

Patel and Thakar (1989) revealed that in pot experiments, fresh and dry azolla and mustard oil cake (both at 800 g/pot) effectively reduced growth of *Tylenchorhynchus vulgaris* population and increased wheat var. Sonalika growth, while castor, Neem, Karanj and farmyard manure did not significantly reduce nematode population over the control.

Novaretti *et al.* (1989) evaluated the effect of compost application alone or in combination with nematicides and mineral fertilizers against *Pratylenchus zeae* on sugarcane. Application of compost alone at 30 t/ha wet matter or more showed low efficacy against nematodes but was beneficial to plant growth. At first harvest all the treated plots had significantly higher yields than untreated plot. Darekar *et al.* (1990) tested Neem, Karanj (*Pongamia glabra*), Mahua (*Madhuca indica*) and castor (*Ricinus communis*) oilseed cakes in a field experiment in furrows and spots

for control of *Meloidogyne incognita* on tomato. All treatments at 400 kg/ha reduced *M. incognita* population and gall index, with Neem and Karanj cake being most effective.

Darekar and Mhase (1990) reported that Neem cake alone or in combination with carbofuran or benfura carb reduced the nematode population of *Meloidogyne incognita, Rotylenehulus reniformis* and *Xiphinema insigne* and increased the yield of grape in Maharashtra, India.

Gill *et al.* (1990) found that linseed (*Linum usitatissimum*), sesame, cotton, castor and mustard oil cakes (each at 13 g/pot) and wheat straw and sawdust (each at 8 g/pot) with NPK depressed *Meloidogyne spp.* as compared to the check.. Linseed and mustard oil cakes gave better control of nematodes than other amendments.

Gopal and Singh (1990) studied the effect of organic amendments on *Meloidogyne incognita* in chickpea. Neem cake, mustard cake, linseed cake, Mahua cake, compost, gober (cattle dung) gas product (biogas) and sawdust were added to soil in microplots 15 days prior to seed sowing. Neem cake caused maximum reduction in the number of root knot nematodes (*Meloidogyne incognita*) followed by sawdust. Jonathan *et al.* (1990) tested the effectiveness of press mud filter cake from cane sugar (dose 25 t/ha) farmyard manure (20 t/ha) poultry manure (20 t/ha) Neem cake (2 t/ha), coir pith (25 t/ha) and sugar cane bay see (25 t/ha) against *Pratylenchus coffeae* and some other nematodes infecting sugarcane.

Neem cake and press mud were observed to be most effective, giving population 81-82 per cent lower than control after 90 days and 60-62 per cent lower after 180 days cane yield C.C.S. were 104.85 t/ha and 14.25 per cent with Neem cake, 92.68 – 99.28 t/ha and 13.80 – 14.18 per cent with other treatments and 88.72 t/ha and 13.90 per cent untreated.

Khan (1992) studied the effect of carbofuran at 10 kg a.i./ha and crushed dry Neem (*Azadirachta indica*) leaves at 8.33 or 1666 kg/ha on *Pratylenchus thornei* and the growth parameters of 3 wheat varieties (Faisalabad-85), Khyber-87 and Sarhad-82 were examined. All the three treatments resulted in increased root weight as well as the thousand grain seed weight. The population level of *P. thornei* was reduced the most by the higher dose of Neem. Sebastien and Gupta (1992) applied groundnut, linseed, mustard and Neem cakes in soil @ 400 kg/ha in *P. thornei* infested fields. 15 days prior to chickpea sowing. There was no significant difference in nematode population per root system at 120 days after sowing among these oil cake treatments through significant increase in shoot and root weight of chickpea at 90 days was recorded with application of mustard and Neem cakes.

Khan *et al.* (1994) tried the leaf extracts of *Azadirachta indica*, *Eucalyptus citriodora* and tobacco on the population density of *Pratylenchus thornei* in soils while only *A. indica* and tobacco extracts reduced the population density of *Hoplolaimus senihorsti* (*Basirolaimus senihorsti*) of the leaf extracts, only *A. indica*

significantly increased the number of spikes and root weight of wheat c.v. Pirsab ak-85.

Sebastian and Gupta (1996) evaluated the groundnut, linseed, musard and *Azadirachta indica* oilseed cakes for control of *P. thronei* on chickpea in field trials in India. Mustard and linseed cakes were most effective in reducing root population of *P. thronei* at 120 days after sowing (DAS). Greatest reduction in soil nematodes population occurred with groundnut cake. Significant increase in shoot and root mass of chickpea at 90 DAS occurred with mustard and A. *indica* cakes.

Shukla and Haseeb (1996) evaluated some nematicides (aldicarb, carbofuran, ethoprophos) and oil cakes linseed (*Linum usitatissimum*), mustard (*Brassica compestris*), Neem (*Azadirachta indica*) against *Pratylenchus thornei* infesting *Mentha citrata, M. piperita* and *M. spicata* in glass house experiments. All the treatments were effective in increasing herb weight and oil yield of all the test species of mint as compared to untreated inoculated plants. However, herb weight and oil yield of plants treatments with aldicarb, mustard and Neem cakes were significantly higher than those of untreated uninoculated plants. All the treatments were effective in minimizing nematode reproduction in all the species of mint. Neem cake was most effective in reducing the reproduction rate of *Pratylenchus thornei* and increased the herb weight and oil yield, followed by mustard cake, aldicarb, ethoprophas, carbofuran and linseed cake, respectively. Efficacy of

different treatments in control of *Pratylenchus thornei* was not much influenced by the plant species.

FERTILIZER APPLICATION :

Upadhyay *et al.* (1974) studied the effect of potassium sulphate super phosphate and urea on survival of nematodes in the absence of host. They reported that in corporation of potassium sulphate and super phosphate into soil naturally infested with nematodes in the absence of host after 24 and 32 days, markedly reduced plant parasitic and saprozoic nematodes, urea also markedly suppressed population after 8 days.

Ismail and Saxena (1977) observed increased development of root knot nematode on tomato at increased dose of potassium. However, Shannon *et al.* (1977) found that with soybean cyst nematode. *Heterodera glycine* yield of both susceptible and resistant varieties were increased.

Rodriquez *et al.* (1978) reported that solution of urea at 2 per cent or higher, significantly reduced galling index, the number of galls and the number of eg/g fresh weight of root of *Cucurbita pepo* infected with *Meloidogyne arenaria.* Lucdders *et al.* (1979) studied the influence of rate and source of potassium on soybean cyst nematode reproduction on soybean seedlings. In a glass house experiment soybean infested with *Heterodera glycine,* were fed with potassium as 'KCL' or "K_2S0_4" at 50, 100, 200 or 400 mg./pot. The number of cysts/100 g soil and the number of cyst/plant were higher with "K" treatment of 50, 100 and 200

mg/pot than in the untreated control, but declined at 400 mg. The decrease in soil cysts was larger in "Kcl" than with "K_2S0_4" treatment.

Badra and Shafee (1979) reported that application of ammonium sulphate or ammonium nitrate at 25, 50, 100, 200, 300, 400 and 500 ppm to one year old seedlings of *Citrus aurantifolia* inoculated with *Tylenchuhus semipenetrans* decreased soil and root population of *T. semipenetrans,* ammonium sulphate treatments gave greater plant growth responses than comparable nitrogen levels with ammonium nitrate.

Juhl (1981) observed that increased amounts of nitrochalk (0-232.5 kg/ha) given to oats grown in *Heterodera avenae* infested soil inhibited reproduction of the nematode.

Gnanapragasan (1982) reported that in pot experiments, increasing the dosage of potassium fertilizer from 554 mg of 'K_20'/plant/year to 1108 mg/plant I year significantly suppressed population of *Pratylenchus loosi* on tea.

Jaehn *et al.* (1983) observed that excess application of "N" and "K" favoured the maturation and multiplication of *Meloidogyne incognita* on coffee tree.

Glazer and Orion (1984) found that exposing adults of *Pratylenchus thornei* to increasing concentrations of hydroxy urea (Hu) or thiourea (Tu) up to 100 ppm was not lethal. Orion *et al.* (1984) reported that nitrogen fertilizer had no effect on

lesion nematode *Pratylenchus thornei* infecting wheat under dry farming condition in the northern region.

Quraishi (1985) reported that in grape vineyards of Hyderabad, nitrogenous fertilizers retarded the population of *Xiphinema, Tylenchulus* and *Rotylenchulus, Helicotylenchs indicus* and *Tylenchulus mirus*. Lapinski (1988) found that ammonia released in the reaction of ammonium sulphate and lime applied to soil, decreased *Ditylenchus* on potato.

Tacconi *et al.* (1988) observed that adding mineral fertilizers (N+P) reduced *Pratylenchus thornei* in wheat roots and this effect was increased if the crop was grown in rotation rather than continuously.

Khan *et al.* (1989) reported that application of urea (3 or 6 g/pot), superphosphate (6 or 12 g/pot) or potassium sulphate (6 or 12 g/pot) to soil infested with *Pratylenchus scribneri* reduced the population of nematodes.

Rebeh and Sweelam (1990) observed that an increase in K nutrition decreased the population of citrus nematodes *Tylenchulus semipinetrans* in the roots of *Citrus reticulata* and in soil.

Thompson, Mackenzie, Amos (1995) studied the cumulative effects of factorial treatment of tillage (no tillage, conventional), stubble retention (burnt retained) and nitrogen fertilizer (0, 23, 69 kg N/ha) on yield of continuous winter cereals and on soil properties in the Hermitage, fallow management experiment

since 1969. Despite increased soil water stored form the combination of no tillage and stubble retention, wheat responses to the extra water were disappointing in the first year of the experiment. Soil samples from the experiment were shown to be heavily infested with *Pratylenchus thornei* and therefore in 1980, the main plots were split for crop, wheat cv. Timgater, barley cv. Clipper, and nematicide treatment (nil aldicarb). Barley maximum yield 3.2 t/ha) tolerated the nematodes and responded in this dry year to the extra stored water accumulated with no tillage and stubble retention, but wheat (maximum yield 1.22 t/ha) did not.

Ivezic, Samota, Raspudic, Horvat (1996) reported that the reduction of 52-60 per cent in nematodes number in maize was achieved in the 1st and 2nd year after potassium application at 330 and 550 kg/ha *Pratylenchus thornei* was dominant.

VERIETAL SCREENING :

Dickerson And Frans (1974) observed reaction of *Phaseolus vulgaris* Great northern 1140 and pinto Idaho 111, as hosts for *Pratylenchus scribneri, Pratylenchus alleni, Pratylenchus hexincisus* and *Pratylenchus neglectus.* Both beans were highly susceptible to *Pratylenchus scribneri* and *Pratylenchus alleni* and both were resistant to *Pratylenchus hexincisus* and *Pratylenchus neglectus* based on nematode reproduction. *Pratylenchus alleni* and *Pratylenchus scribneri* were inoculated onto six varieties of *Glycine max.* The varieties Columbus, Williams, Cutter, Colland and Wayne were resistant to both nematodes while Clark 63 were resistant to *P. alleni* but susceptible to *P. scribneri.*

Schmidt (1976) studied the relative suitability of soybean cultivars to *Pratylenchus brachyurus* when 26 soybean cultivars were evaluated for host efficiency to *Pratylenchus brachyurus* in green house tests. The initial nematode population was 213 larvae and adults per pot. On the basis of comparisons between plants grown in fumigated soil and those grown in non fumigated soil shore and coker 74-478, were the only cultivars which were stunted by fewer than 6000 *P. brachyurus* per gram of over dried root on coker 72-260, coker 338 Dari, Davis, me nair 600, Ranson, SRF – 450, tracy and york. Cultivars that tolerated population densities greater than 6000 per gram of root without apparent damage were Bragg. Coker 73-376, FFR 555, FFR 6024, Hutton and lee 68, Root growth of shore, esse and semmes was suppressed more than shoot growth by *P. branchyurus* roots were 46, 43 and 33 per cent and shoots were 25, 32 and 24 per cent less respectively than those of fumigated controls and root weights were 4, 12 and 23 per cent lower respectively than controls. Roots of less 74, forest and coker 74-478 weighed 33, 26 and 23 per cent less respectively than the fumigated controls but the these were no difference in shoot weight.

Smith *et al.* (1978) tested six introduction and two varieties of peanut for resistance to *Pratylenchus branchyurus,* P. 1295233 and P-1290606 had less pod discolouration and fewer nematodes in the shell and rot tissue than stars and spans cross. The other introduction also showed some resistance.

Acosta (1979) conducted a preliminary glass house screening of 51 soybean cultivars for resistances to *Pratylenchus scribneri* and indicated a wide range of susceptibility. Re-evaluation of 12 cultivars showed Clark 63, Wood Worths and Williams to be highly susceptible and Custer, Syer and for rest to be resistant. Cornety was the most intolerant. Walia (1982) tested six chickpea varieties (BG-203, BG-212, H-208, C-235, Pusa-209 and L-550) against *P. thornei* in pot experiment. The root population was least in L-550 and maximum in Pusa-209.

Out of 49 gram varieties screened against *Pratylenchus thornei* at Jabalpur during 1989-91 under All India Co-ordinated Research Project on Plant Parasitic nematodes, 6 varieties were found to be resistant to *Pratylenchus thornei.* They were PDG-83-84, ICCV-43, KPG-24, H-8360, BG-329 and ICCC-42. Lordello *et al.* (1985) evaluated 3 maize cultivars in an area infested with *Pratylenchus spp.* at two sowing dates. In field trials, sown in October and December 1963, of 3 varieties, know to be resistant, intermediate and susceptible on plots infested with *P. zeae* and *P. brachyurus* with and without nematidical treatment.

Pratylenchus populations per gram of root tissue were assessed 85 days in the first trials at 75 days in the second trial after sowing. The results obtained were in close accord with the indications of relative resistance provided by grain yields in the same material. They concluded that the assessment of *Pratylenchus* populations per gram of root tissue can provide acceptable estimates of resistance. Sawazaki *et al.* (1987) investigated about the inheritance of corn resistance to *Pratylenchus spp.*

in infested Brazilian maize fields. The study was conducted by using lines of col. 2(22) resistant and 1 p. 48-5-3 susceptible, the generations F_1, F_2 and back crosses. The genotypes were sown in a field infested with *P. zeae* (76 %) and *P. brachyurus* (24 %), eighty days after planting the number of nematodes per gram of roots was determined.

Greco *et al.* (1988) evaluated ninety seven lines of Kabuli and Desi chickpea germplasm in a field infested with *Pratylenchus thornei* in Syria to find susceptibility. At the end of experiment four chickpea roots collected from each chickpea lines sown as a single row in 4 plots were incubated for 48 hours and nematodes in the water suspension were counted. All chickpea lines tested in the field were susceptible to *Pratylenchus thornei.* Low infestations of the nematodes ranging from 32-58 specimens per 5 g root were observed on few lines. On remaining lines the attack was high and in some of them up to 650-nematodes/5 g root was counted.

Marull *et al.* (1990) evaluated five almond (*Prunus amygdalus*) cultivars for their reaction to *Pratylenchus vulnus, Pratylenchus neglectus* and *P. thornei* under green house conditions at 120 days after the inoculation with 1000 nematodes/plant and reported that *P. thornei* multiplied poorly on almond indicating that the plant was not host.

Townshed (1990) reported methods for evaluating plant species for resistance to *Pratylenchus* species. He suggested that the criteria; for evaluating

resistance were considered to be the ability of the nematodes to reproduce in a host and the response of the host plant to attack.

Corbett *et al.* (1969) studied the population development of *Pratylenchus thornei* in broad back, England. Population decreased under fallow and increased when wheat was planted. *Pratylenchus spp.* invaded the root of young wheat seedlings and multiplied there throughout the winter.

Johnson *et al.* (1974) examined soil samples from the plants of maize, cotton, peanut and soybean at Tifton, Georgia, U.S.A. during 1968-1971. Their studies revealed that *Pratylenchus spp.* (mainly *P. zeae*) were always more numerous on maize and soybean than other two crops, except during May to July. Kinloch and Lutriek (1975) compared the nematode population level from 1971 to 1974 in soil under various cropping sequences in Florida, U.S.A. They concluded that the number of *P. zeae* remained high with maize and sorghum.

Meassen (1977) revealed that the number of *Pratylenchus spp.* in soil in a maize crop field decreased from May to July and then increased to a maximum in November. Numbers in roots increased and those in soil decreased in July. 2 per cent of the population of *Pratylenchus* was in soil and 98 per cent in maize roots. The nematodes multiplied in the roots in August so that in September 36 per cent of the populations was in soil and 64 per cent in roots with the decay of roots in November, all the nematodes left the roots and were found in the soil.

Rodriguezkabana and Collins (1980) investigated the soil and root population of *Pratylenchus scribneri* in a continuing 3-year rotation scheme of summer crops of corn, soybean and cotton followed respectively by wheat fallow and mixed common vetch and crimson clover. Among the summer crop highest numbers of the parasite were detected in plots with corn, followed by soybean and cotton. The inclusion of wheat or winter legume in the rotations sequence resulted in low number of *P. scribneri.* Acosta (1982) studied the vertical distribution of *Pratylenchus alleni* and *Scribneri* in the soybean roots. Populatinos of both nematode species were most abundant in the first 10-15 cm of the root zone of dark 63 soybean, 30 days after planting. There was a distinct decrease in nematode population density in both species with depth of the taproot. Walia (1982) studied the seasonal fluctuation of *Pratylenchus thornei* in Delhi area, under green gram – maize chickpea sequence of crop rotations and observed that *P. thornei* population was decreased on green gram and increased on maize and chickpea.

Koenning *et al.* (1985) investigated about the influence of planting date on population dynamics and damage potential of *Pratylenchus brachyurus* on soybean at two locations in North Carolina, U.S.A. An initial population slightly less than the damage threshold of (275) nematodes/500 cm^3 soil was used minimize the influence of host damage on this nematodes population dynamics and to gain greater precision in characterizing factors which influence the damage potential of *P. brachyums* to soybean. Early planting of soybean also resulted in greater

population densities of *P. brachyurus* at mid season, which often persisted until soybean harvest. Length of time for reproduction and intra specific competition occurring when soybeans were stunted by this nematodes, were the most important factors influencing dynamics of *P. brachyurus.*

Fawale and Mai (1988) found in green house experiments, that the population density of *Pratylenchus penetrans* was significantly higher in a potato-rye-potato cropping system than in a potato-clean fallow-potato system. They observed this due to high population of *Pratylenchus penetrans* in rye roots.

Abd-Elgawad and Saad (1989) investigated populations dynamics of *Pratylenchus spp.* on common bean as affected by intercropping with maize in Egypt. Higher population of nematodes occurred when *Phaseolus vulgaris* was intercropped with maize than when grown in pure stand. In a survey of carrot crops and plant grown in rotation with carrots in Prince Edward Island, Canada. Diamond *et al.* (1991) observed that *Pratylenchus penetrans* were most prevalent in red clover hay potato fields.

Esmenjaud *et al.* (1990) evaluated the effect of crop rotation on *Pratylenchus* population in three locations in Northern France. They reported that *P. thornei* was most numerous on winter wheat after maize. Sugar beat when integrated as the previous crop decreased populations of *Pratylenchus thornei.*

CHAPTER -3

MATERIALS AND METHODS

CHAPTER- III

MATERIALS AND METHODS

As per objectives given in the introductory paragraph, the details of various materials used and methods followed in the thesis entitled, "Studies in management of lesion nematode (*Pratylenchus thornei*) problem on chickpea (*Cicer arietinum*)" are discussed below.

A. Survey :

An extensive survey was undertaken to know the incidence of *Pratylenchus thornei* infestation in major chickpea growing area in the Allahabad district. The blocks and villages selected were –

Karchana block : Village : Piprow, Jagdishpur, Dioha, Bashahi, Vedo, Bherpur, Rawanica, Kabara, Shemraha, Talia and Panasha.

Chakka block : Village : Dandi, Dabhawa, Mahewa and Mamabhanje ka Talab.

During the survey, soil samples from around affected plants root material were collected in polythene bags and properly labelled. The soil samples were collected as per prescribed procedure and processed and examined for population of *Pratylenchus thornei* by adopting standard techniques.

1. **Selection of experimental field :** The various pot experiments were conducted at Department of Plant Pathology Nematology, Allahabad Agricultural Institute,

Allahabad. The micro plot experiment were conducted at village Piprow near 3 km distance Bherpur railway station, the farmer's or experimental field is naturally infested at Allahabad district.

2. **Selection of host crop :** Local and 250 Pusa variety of gram (*Cicer arietinum* L.) was selected for the present studies.

Nematode parasite : The pathogen used for the studies was *Pratylenchus thornei* **(Sher and Allen, 1953).**

B. Preparation of inoculum :

1. **Cleaning and sterilizing of pots and Soil :** Earthen pots were washed with water followed by rinsing in 40 per cent formaldehyde and dried for all pot experiment field soil collected from department of Plant Pathology and Nematology, Allahabad Agricultural Institute. Experimental or farmer's field soil was also used. It was sieved and filled in gunny bags and kept in autoclave at zolbs pressure for 5 hours, cooled and filled in 10 cm earthen pot.

2. **Initiation of culture :** Required amount of soil was collected from the identified infested field from a depth of 16-18 inches during the second week of September and field in clean 30 cm earthen pots and seeds of gram were sown to establish nematode culture.

3. **Maintenance of culture :** For maintaining culture, one 2m x 2 m microplot in the Department of Plant Pathology and Nematology experimental field was

selected to take upper soil of the plot and mixed with pot soil. Gram seeds were sown during winter and summer seasons respectively.

4. **Extraction of nematodes :** (1) INFECTED ROOTS : Plants were uprooted from culture pot/micro plot as per the requirement of respective experiments. The roots were gently washed to remove the adhering soil and cut into small pieces of about one cm each. These root pieces were blended for few second (40-45 sec.) in waring blender. The homogenised roots were further processed by using modified Baermann funnel technique **(Christie and Perry, 1951; Schindler, 1961).** They were placed over a Petridish assembly, consisting of moulded aluminium sieve of wire gauge, which has a smaller diameter than the top rim of Petridish and mounted with two crossed layers of tissue papers with water just enough to be in contact with the roots, the suspension was collected every day for one week, replenishing the water when required.

The nematodes suspension collected from several such Petridishes was mixed together and concentrated to a desired volume.

(2) INFESTED SOIL: Infested soil samples (an aliquot of 500 g each) were processed for nematodes, extraction according to Cobb's Sifting and gravity method (1918) which consist of a series of steps. At each time, soil particles (in water suspension) heavier than nematodes settled to the bottom more quickly, were discarded and lighter, floating nematodes along with some soil particles etc. were collected on sieves (60, 100, 200 and 300 mesh). The residues

collected over the sieve of 100, 200 and 300 mesh were transferred to a beaker and further processed by modified Baermann funnel technique (**Coristicad Perry, 1951 and Schindler, 1961**) described above.

5. **Counting of nematodes :** The volume of the nematodes suspension was collected and measured before counting, the suspension stirred well by blowing through pipette to ensure uniform distribution at the population. A part of the suspension was withdrawn with the help of a pipette and 5 ml of it was released in a counting dish. Three such counts were made and the mean per ml suspension was calculated. The total number of nematodes in whole suspension was calculated by multiplying number of nematodes per ml with total volume of nematode suspension and this was recorded as *Pratylenchus thornei* population per 500 g or for the known weight of roots.

C. Killing and fixing of Nematodes:

For morphological study nematode were killed and fixed nematodes suspension collected in beaker was left undisturbed, allowing nematodes to settle down at the bottom, the excess of water was decanted and concentrated suspension was obtained. The equal amount of double strength boiling F.A. (4:1) fixative was added to kill and fix the nematodes at the same time. The fixed suspension was stored in small collection tubes. The composition of single strength formal – acetic fixative is given below.

Formalin (40% formaldehyde)	-	10 ml
Glacial acetic acid	-	2 ml
Distilled water	-	88 ml

Double strength fixative was made up using half the amount of water indicated above.

D. Preparation of permanent mounts:

The nematodes were transferred from the fixative to a small cavity block containing 2 ml at the following –

(Solution No. 1) :

96 % ethanol	-	20 parts
Glycerol	-	1 part
Distilled water	-	79 parts

The cavity block was placed in a desicator (containing about $1/10^{th}$ of its volume at 96 % ethanol) and left to this in alcohol saturated atmosphere for 12 hours. This removed almost all the water and left nematode in a large volume of a mixture of glycerol and ethanol. The nematodes were then transferred to a cavity block containing solution No. 2 Five parts glycerol and 95 parts ethanol, which was partially covered with a cover glass to allow slow evaporation of ethanol, later cavity block with nematode was transferred to a desicator with calcium chloride and allowed to remain for few days prior to mounting in glycerine.

E. Making of permanent mounts:

A small drop of pure anhydrous glyceral was placed in the centre of a clean glass slide. The nematodes were transferred with a handling needle to the centre of the drop, so that they were resting on the glass surface. Three pieces of glass fibre of about the same thickness to that of nematodes were arranged readily and peripherally. A clean round cover slip was placed on the drop, the cover slip was sealed with a quickfixed or best quality nail polish twice.

F. Measuring of nematodes :

Measurements of stylet length, body width, length of oesophagus etc. were made using a micrometer scale (Ocular Micrometer) inserted into the eyepiece of a high power microscope. The division of the eye piece scale were calibrated for each objective of the microscope. Earlier by comparing them with the divisions (each division being 10 micron) on the micrometer slide (Stage Micrometer) placed on the microscope stage. The measurements of the nematodes were expressed in terms of Deman's formula (Sauthey, 1970).

$$a = \frac{\text{Total length of body in mm}}{\text{Total width of body at Valva}}$$

$$b = \frac{\text{Total length of body}}{\text{Oesophagus length from leps to intestine Valva}}$$

$$c = \frac{\text{Tolal length of body}}{\text{Length of Tail}}$$

$$v = \frac{\text{Distance of Valva form lips in present}}{\text{Total body length}} \times 100$$

G. Drawing nematode :

Camera lucida (prism type) was used for drawing the nematode.

H. Pathogenicity study :

A pot experiment for studying the effect of different inoculum levels of *P. thornei* on the growth of gram seedlings. Seeds of gram were surface sterilized with 0.1 per cent mercuric chloride for a 5 minutes, washed three times with sterilized water and sown (2 seeds per pot) in 6 earthen pots filled with sieved and sterilized garden soil. Seven days old seedlings were inoculated with *P. thornei* as per detail given below :

Treatments –

(1) T_0 - Control

(2) T_1 - 500 nematode / Pot

(3) T_2 - 1000 nematode / Pot

Observations recorded:

The following observations were recorded at 30, 60 and 90 days after sowing except for final shoot weight, root weight, nematode population within the roots which was recorded at 90 days after sowing.

a- Shoot length and weight

b- Root weight

c- Number of nematodes per root system

d- Number of nematodes per gram of root.

Each treatment was replicated three times. The pot were labelled and arranged in a completely randomised fashion and maintained for three months.

I. Management of chickpea crop in *Pratylenchus thornei* :

(1) Pot experiment of nematicides against *Pratylenchus thornei* :

Surface sterilized gram seeds were sown in 6" earthen pots (2 seeds per pot) filled with 500 sieved and sterilized garden soil treated as per the details outline below. Seven day old seedlings were inoculated with nematode suspension at the rate of 1000 nematode (adults and larva) per pot maintaining 3 replicates of each treatment.

Details of treatments :

1. T_0 - Control
2. T_1 - 1000 nematodes
3. T_2 - 1000 nematodes + carbofuran @ 0.2 g a.i./m^2
4. T_3 - 1000 nematodes + phorate @ 0.2 g a.i./m^2

Observation recorded :

a- Plant growth parameters recorded at 30, 60 and 90 days after sowing
   1. Shoot length
   2. Shoot weight
   3. Root weight

b- Nematode population at 90 days after sowing
   1. Number of nematodes per root system
   2. Number of nematodes per root

(II) In farmer's field naturally infested with *P. thornei* :

Two granular nematicides (Carbofuran 3G and Phorate 10G) were applied in infested farmer's field like that 1995-96 at Dabhawa and 1996-97-98 at piprow in Allahabad in 2 m x 2 m micro plot at the rate of 2 kg a.i./ha (Carbofuran 30 g/45 g and phorate 10g/45g). There were three treatments, each having three replicates 1995-96 and four replicates in 1996-97-98.

Treatments –

1. T_0 - Control (untreated)
2. T_2 - Carbofuran 3G
3. T_2 - Phorate 10G

Observations recorded (1995-96*, 1996-97, 1997-98) :

Observations were recorded in the above experiments on *P. thornei* population per 500 g soil at pre-sowing, 30, 60 and 90 days after sowing at post harvest stage. *P. thornei* population per gram root, shoot and root weight in g, shoot length in cm, number of nodules per two plants, weight per 10 nodules at 45, 75 and 105 days after sowing was also recorded.

Field experiments :

Total five oil cakes were used 1995-96 Neem (*Azadirachta indica*), soybean (*Glycine max* L., mustard (*Brassica compestris*), linseed (*Linum usitatissimum*) at Dabhow village farmer's field and 1996-97-98. Neem, mustard, linseed and Mahua

(*Madhuca indica*) at Piprow village farmer's field in Allahabad. Oil-cakes were applied in 2m x 2m plots at the rate of 1000 kg/ha (500 g/45 g) and allowed to decompose for 15 days before sowing.

Effect of cultural practices:

Mixed cropping and intercropping practices in naturally infested farmer's field at Dhabhow and Piprow village in 1995-96, 1996-97, 1997-98.

1. Mixed cropping : Seeds of chickpea (*Cicer arietinum*) with Wheat (*Triticum aestivum*), (Fig-11) Pea (*Pisum sativum*), (Fig-9) Linseed (*Linum usitatissimum*),(Fig-10) Barley (*Hordeum vulgare*) (Fig-12) were mixed in recommended seed rates and sown by to broadcasting in infested field with chickpea alone as control. (Fig -13)
2. Intercropping : (1996-97, 1997-98) seeds of chickpea with Wheat,(Fig-7) Pea (Fig-5), Linseed (Fig-6), and Barley (Fig-8) in recommended rates were sown in infested field in alternate row with chickpea alone as control.

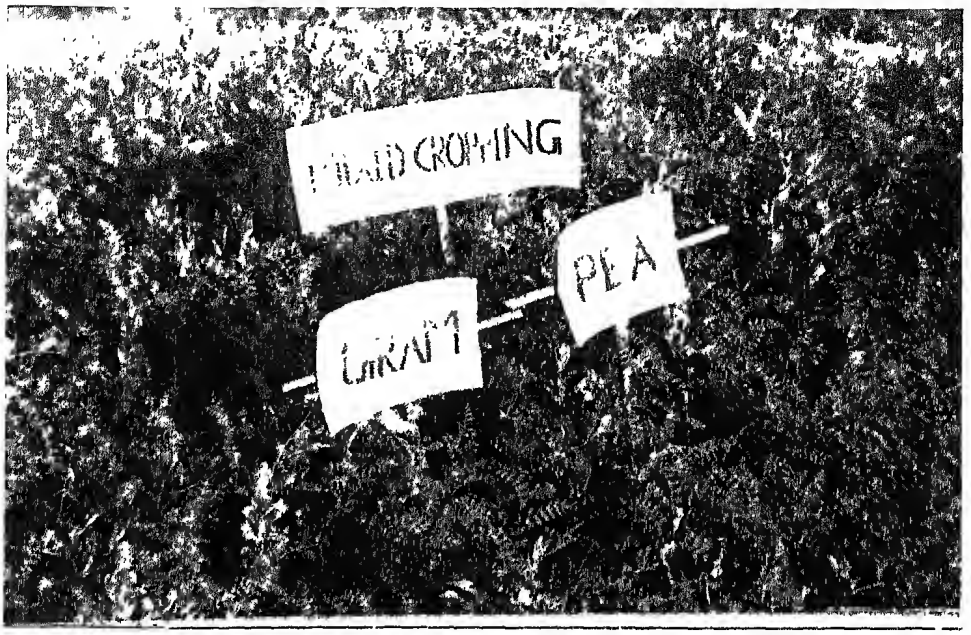
Screening of Gram germplasm:

124 varieties in 1995-1996 and 1997-1998 167 varieties of chickpea obtained from I.I.P.R., Kalyanpur, Kanpur were screened in naturally infested farmer's field at Dhabhow and Paprow village.

Observations recorded (1995-96, 1996-97)

Observations recorded per gram of root *P. thornei* nematodes.

Fig – 9



Management of lesion nematode through mixed cropping with combination of Pea and Gram.

Fig – 10

Management of lesion nematode through mixed cropping with combination of Gram and Linseed.

Fig – 11

Management of lesion nematode through mixed cropping with combination of Gram and Wheat.

Fig - 12

Management of lesion nematode through mixed cropping with combination of Barley and Gram.

Fig –5

Management of lesion nematode thourgh intercropping with combination of Pea and Gram.

Fig – 6

Management of lesion nematode through intercropping with combination of Gram and Linseed.

Fig –5

Management of lesion nematode thourgh intercropping with combination of Pea and Gram.

Fig – 6

Management of lesion nematode through intercropping with combination of Gram and Linseed.

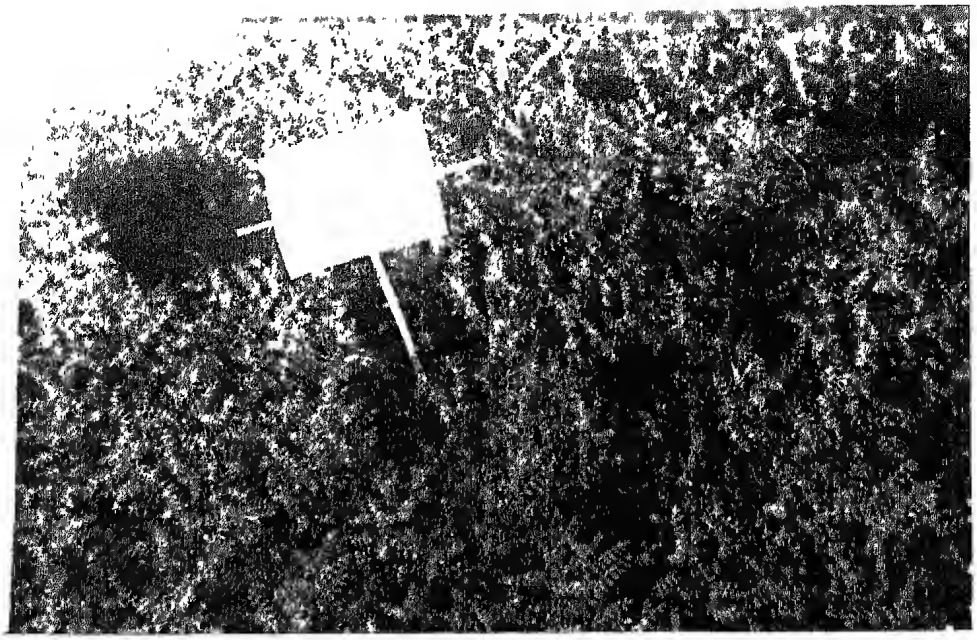
Fig – 7

Management of lesion nematode through intercropping with combination of Wheat and Gram.

Fig – 8

Management of lesion nematode through intercropping with combination of Barley and Gram.

Fig – 13



Chickpea control plot.

Fig - 14

Screening of chickpea varieties.

Effect of seasonal fluctuations of *P. thornei* population in two infested fields

Two locations viz. one in traditionally gram growing farmer's field Piprow, Allahabad and another in the artificially developed sick plot at Departm of Plant Pathology and Nematology, A.A.I., Allahabad were selected for the stu of seasonal fluctuations in population of *P. thornei*. At each sampling date, s samples comprising of a composite of 500 g were collected at 6", 12" and 18" dep from fixed identified sites in each of two locations for a period of one y (Oct. 1996 to Spt. 1997). Soil samples were processed and *P. thornei* populati was estimated as per the methods outlined earlier for soil processing and counting.

CHAPTER -4

RESULTS

CHAPTER-IV

RESULTS

The details on identification and taxonomy of nematode pest along with symptoms produced on infected host as well as the experimental results on the "Studies in management of lesion nematode *Pratylenchus thornei* problem on chickpea (*Cicer arietinum*) are given below.

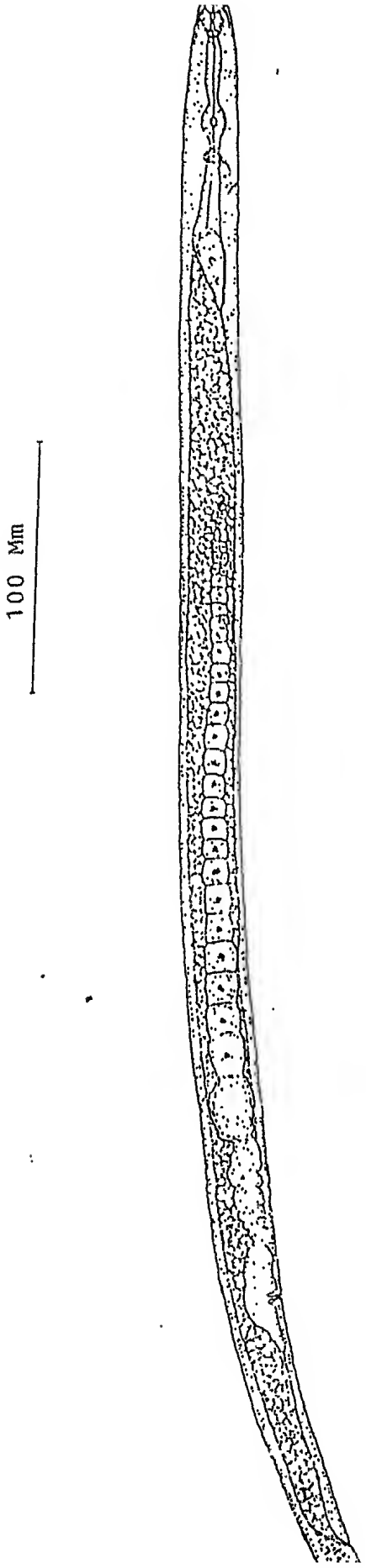
A. Identification of nematode pest *Pratylenchus* Fidipjev, 1936.
Description :

Small, cylindrical nematodes less than 0.8 mm in length with annualated head, lip area low, flattened anteriorly, not or weakly set off. Oesophageal glands overlapping ventrally the intestine for a medium distance. Oesophageo intestinal valve well developed. Female genital tract with posterior branch reduced, post vulval sac (Prodelphic). Female tail length 2 to 3 times the and body diameter, terminus rounded. Phasmids situated at mid-tail or slightly posterior. Males rare or unknown in some species.

***Pratylenchus thornei* Sher and Allen, 1953.**
Dimensions :

Female : (n = 109) L = 0.41-0.77 mm; a = 25-36, b = 5.4-8.3, c = 18-25, v = 73.80, stylet = 15-19μ.

Fig –1



Adult female of
Pratylenchus thornei

Description :

Body assumes an open 'C' shape, lip region continuous, conical, high, marked with three annules, outer margin of heavily sclerotized labial frame work extends conspicuously into body lateral sclerotization. Stylet knobs broadly rounded. Lateral field with four incisors, with the outer one's weakly crenate extending beyond phasmids.

Oocytes arranged in single row except for multiple rows near anterior end, spermatheca functionless, difficult to see. Post uterine branch more than one vulval body width long. Phasmids in posterior half of tail. Tail bluntly rounded with smooth terminus (Fig.-1).

With respect to morphological features this nematode pest agrees with description of *Pratylenchus thornei* and is classified as follows (Maggenti *et al.*, 1987).

Phylum	Nemata
Class	Secernentea
Sub-class	Diplogasteria
Order	Tylenchida
Sub-order	Tylenchina
Super family	Tylenchoidea
Family	Pratylenchidae
Sub-family	Pratylenchinae
Genus	*Pratylenchus*
Species	*P. thornei*

B. Survey :

Survey for prevalence of *Pratylenchus thornei* in Allahabad district causing lesion nematode disease in chickpea.

Firstly selected naturally infested of most chickpea growing area of the district and soil sample were collected during 1996-97 by random sampling from (15) fifteen villages (Table 1, Graph-1) and average population of the nematode per 500g soil (*Pratylenchus thornei*) were calculated.

The results (Table 1) evidence that the population of the lesion nematode showed vast variation in different villages of the district. The highest population of the nematodes was recorded from the sample collected from Piprow village followed by Panasha. The lowest population was noted from the soil sample of Mahewa followed by Dandi. It is noticed from the results that there is a vast variation in having highest and lowest population of the nematodes . These villages can be categorised in order of ascending order Mahewa, Dandi, Rawanica, Dabhawa, Berpur, Bashahi, Jagdishplur, Mamabhanje ka Talab, Kabara, Talia, Vedo, Shmraha, Diha, Panasha, Piprond. According to population of the nematode the villages can be grouped

<100 within 1000 Mahewa, Dandi and Rawanica
< 400 within 1200 Dabhawa, Sherpur and Bashahi
<800 within 1400 Jagdishpur, Mamabhanje ka Talab, Kabara, Talio and Vedo
<800 within 1600 Shemraha, Diha and Panasha piprow.

Table 1. Survey conducted in chickpea grown field naturally infested with *Pratylenchus thornei* in two blocks namely Karchchana and Chakka of district Allahabad, 500 g soil 1996-97

Block	Nematode popu. (500 g soil)
Karchchana	
Village	
Pipraw	980
Jagdishpur	479
Diha	744
Boshali	392
Vedo	682
Bherpur	215
Rawanica	95
Kabara	594
Shemraha	713
Tolia	612
Panasha	852
Chakka	
Dandi	45
Dabhawa	152
Mahewa	32
Mamabhanjedra Talabe	532

Scale of rating: 0-100, Normal, 100-400 Moderate, Infested 400-600

Graph:1. Survey conducted in chickpea grown field naturally infested with *Pratylenchus thornei* in two blocksnamely Karchchana and Chakka of district Allahabad, 500 g soil 1996-97

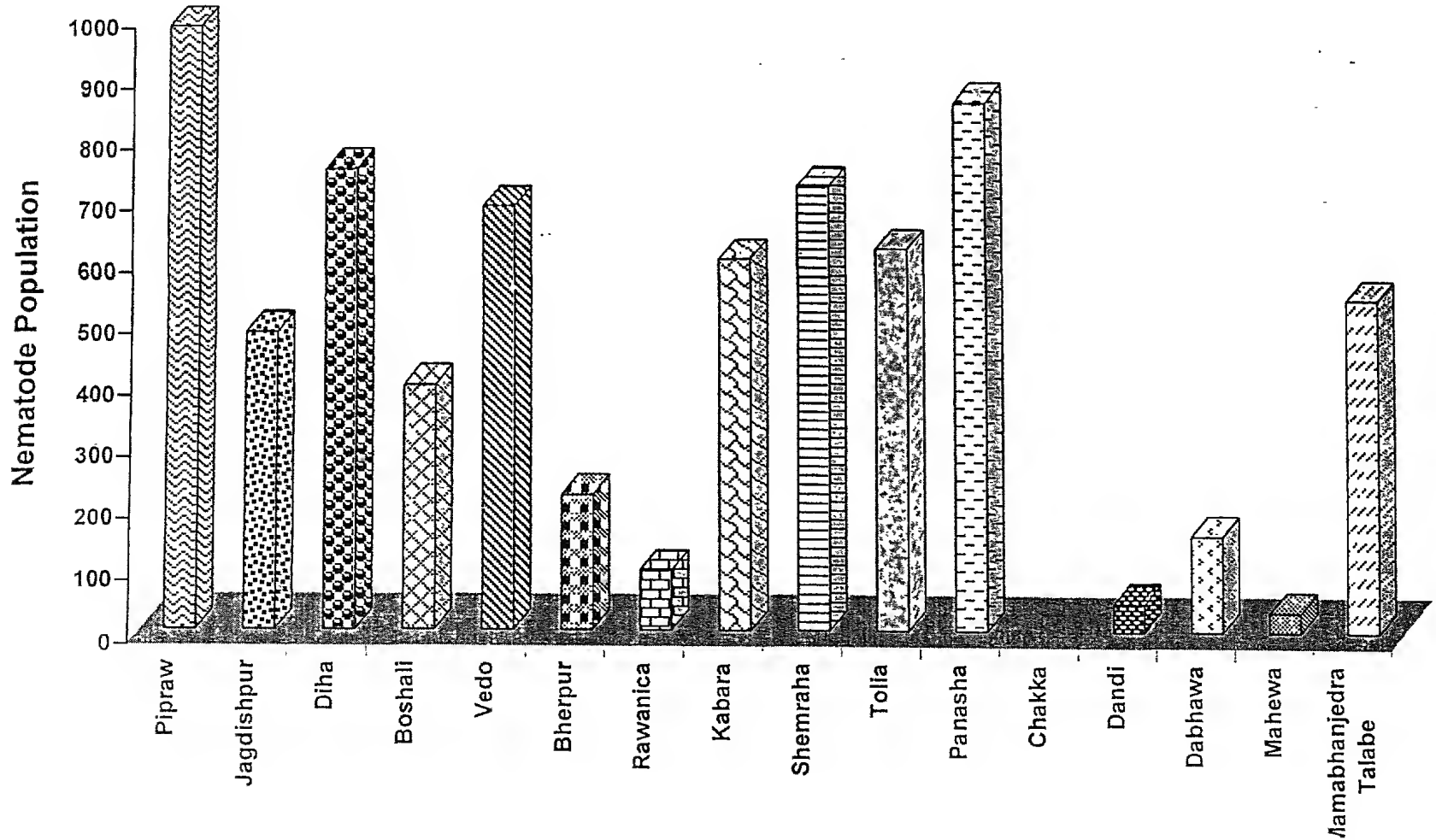
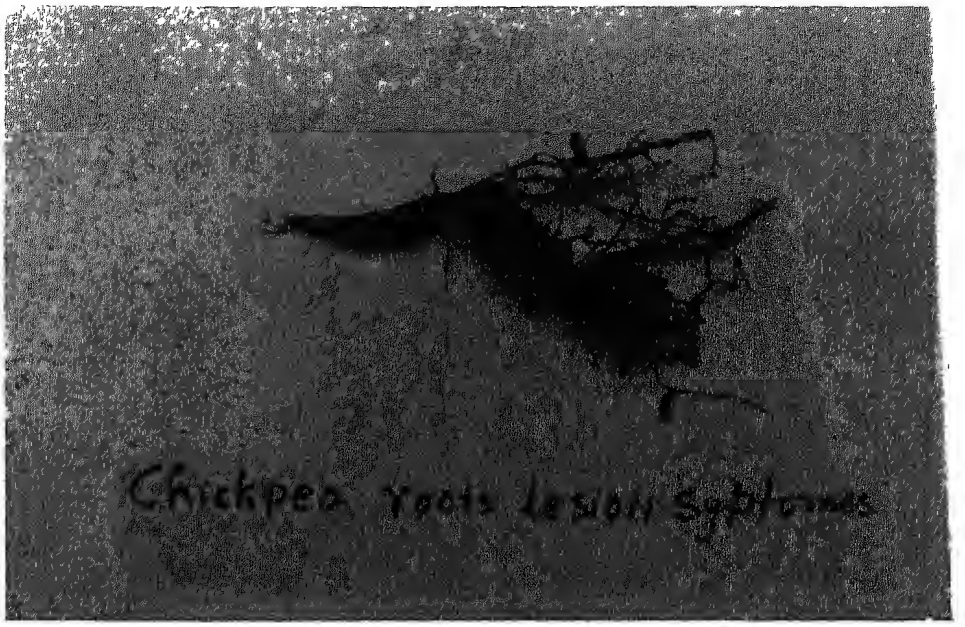


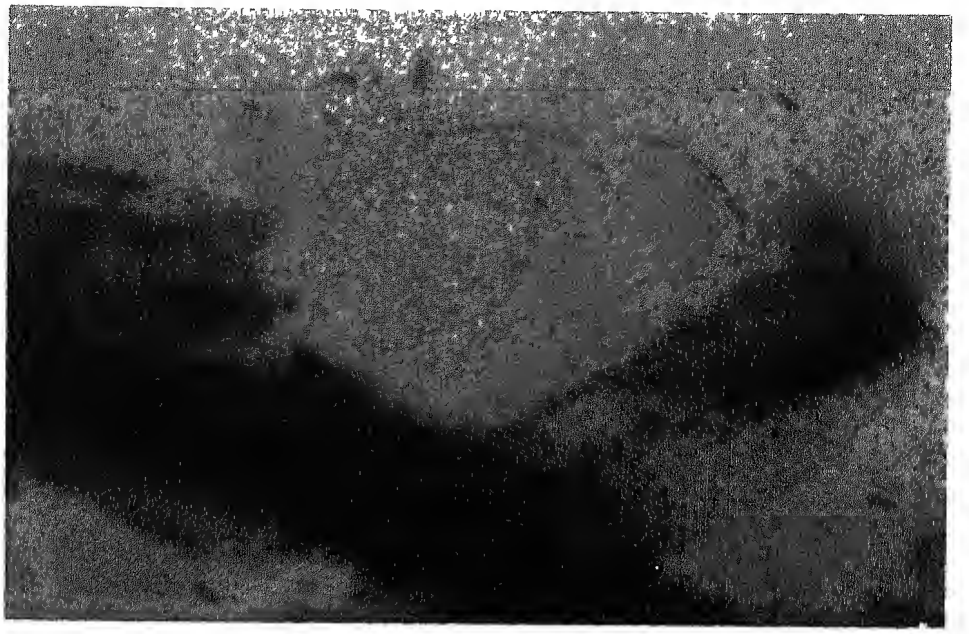
Fig –2



Typical symptoms on chickpea root infected with lesion nematode (*P. thoreni*)

Fig –2 A

Fig –3



Nematode infected chickpea roots teased to show eggs, larvae and adults females of *P. thornei.*

Fig –4

Showing Egg larve and adult female of *P. thornei* extracted from chickpea root (400 times)

C. **Symptoms on the infested plant (gram) :**

Infected plants showed moderate to severely stunted growth with yellowish to chloritic leaves. Stunting of tops followed by loss of primary roots and severe prunning of roots were some of the other symptoms associated with the infection of lesion nematodes. At the initial stage of infected, roots showed tiny elongate, water soaked lesions which later turned brown to almost block (Fig.2,2A). The lesions enlarged, gradually colasced and ultimately girdled the root giving an impression of constriction. When these roots were examined under dissection microscope, adult females, eggs and juveniles of *P. thornei* in various stages of development were seen. (Fig-3 & 4)

D. Experimental results

1. Pathogenicity trial of *Pratylenchus thornei* :

The results on effect of two inoculum levels of *Pratylenchus thornei* on plant growth and the nematode population (conducted as pot trial) are included in Table 2, Graph-2,2A (Fig-3,4)

(a) Effect on plant growth

(i) Shoot length :

At 30, 60 and 90 DAS, shoot length was significantly less in T_1 (500 nematode/pot) and T_2 (1000 nematodes/pot) compared to T_0 (control), the order being $T_2 < T_1 < T_0$; treatment, T_1 and T_2 were not significantly different from each other at 30 DAS at 60 and 90 DAS shoot weight in T_2 was significantly less than T_1.

(ii) Shoot weight :

The shoot weight at 90 DAS was significantly less in all nematode inoculated plants compared to control. The weight of plants in T_1 and T_2 was

significantly differed from each other. The order of shoot weight being $T_2 < T_1 < T_0$.

(iii) Root weight :

The data on root weight at 90 DAS indicates that the weight was significantly less in all nematode inoculated plants compared to control. The weight of plants in T_1 and T_2 was not significantly different from each other, being in the order $T_2 < T_1 < T_0$.

(b) Effect on nematode population :

(i) Nematode population per root system :

At 90 DAS, the number of nematodes per root system was significantly high in plants inoculated with 1000 nematode (T_2) compared to 500 nematodes (T_1). The rate of multiplication in relation to initial inoculum level was higher in plants inoculated with 500 nematodes, being 2.5 times compared to T_2 (1000 nematode); being 2.6 times.

(ii) Nematode population per gram of root :

The number of nematodes per gram of root in the two treatment was recorded in the order $T_1 < T_2$; and T_1 and T_2 were not significantly different from each other.

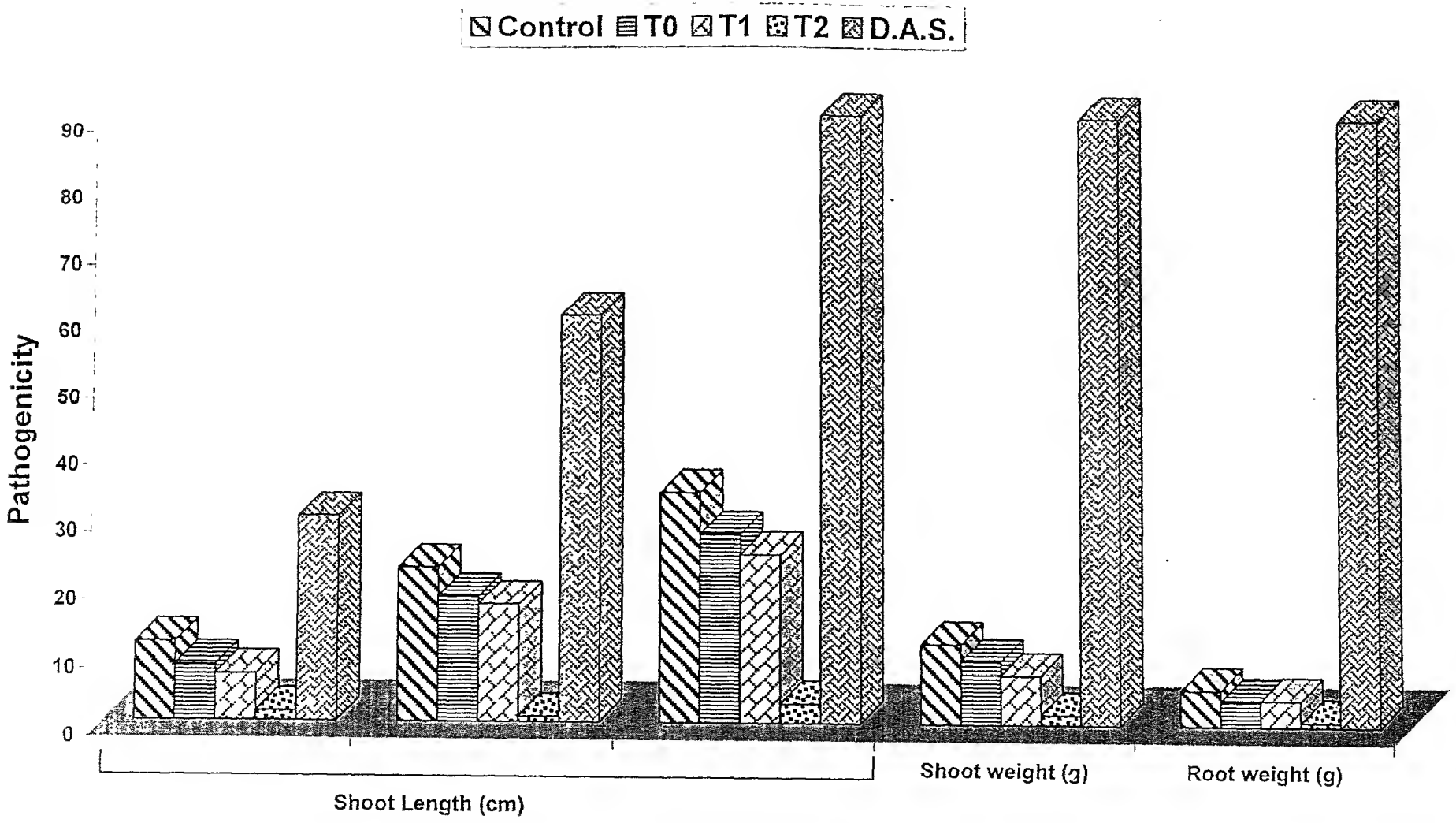
2. Evaluation of Nematicides against *Pratylenchus thornei* :

Effect of Carbofuran (T_2) and Phorate (T_3) application on plant growth and nematode population is recorded in Table 3 and Graph-3.

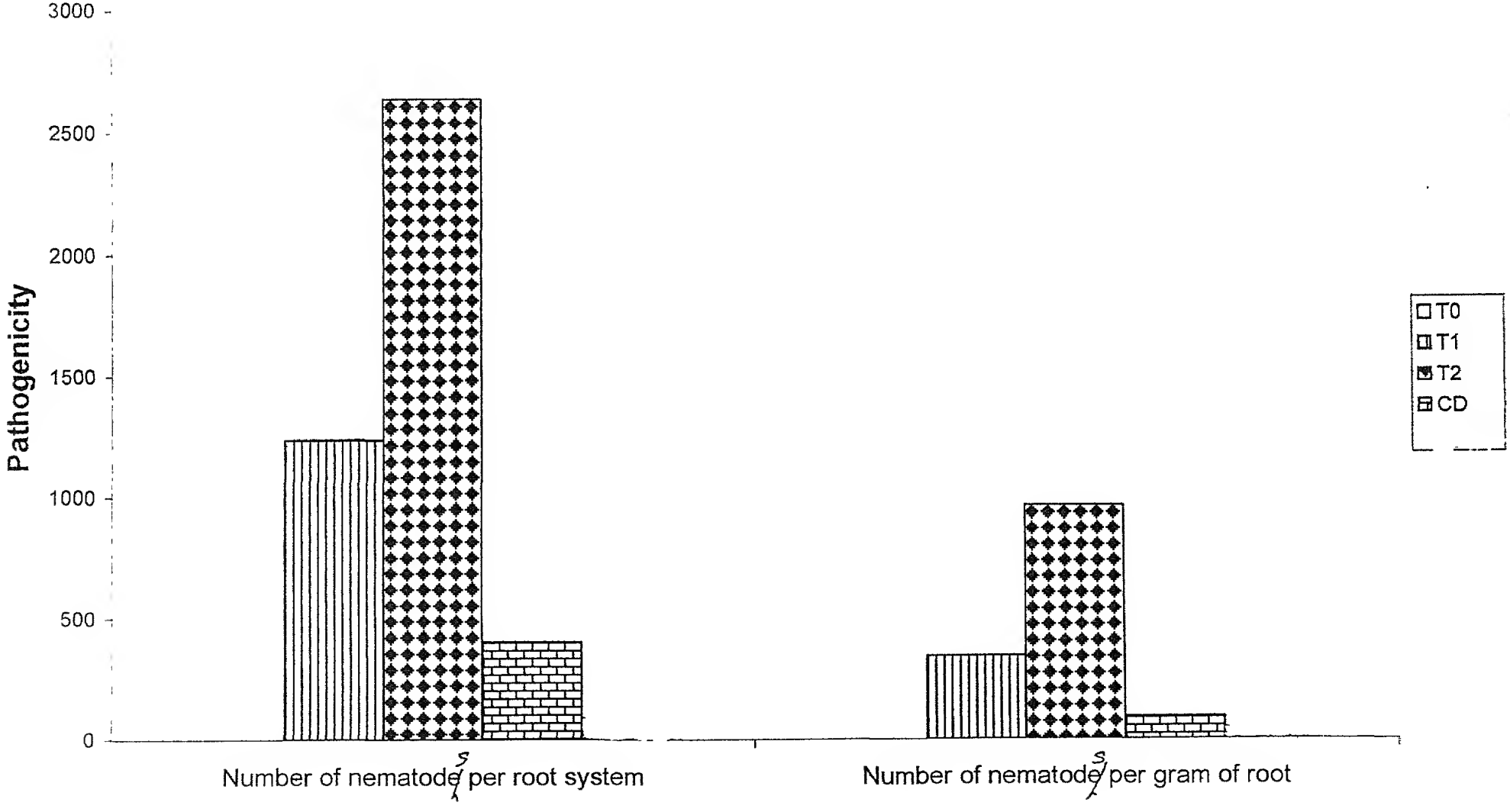
Table 2. Pathogenicity of *Pratylenchus thornei* on chickpea (pot experiment) 1996-97

Observation	D.A.S.	Control T_0	500 Nematodes T_1	1000 Nematodes T_2	CD at 5%
Shoot Length (cm)	30	11.43 (10.9-12.02)	8.10 (7.5-8.6)	6.77 (6.4-7.0)	1.4
	60	22.43 (21.9-22.9)	18.23 (17.6-18.9)	17.07 (16.5-17.8)	0.79
	90	33.77 (32.6-34.8)	27.53 (26.7-28.0)	24.53 (22.9-26.2)	2.8
Shoot weight (g)	90	11.6 (10.6-12.7)	9.17 (8.7-9.9)	7.10 (6.9-7.4)	1.47
Root weight (g)	90	5.2 (4.9-5.5)	3.7 (3.2-4.2)	3.8 (3.5-4.0)	0.68
Number of nematodes per root system	90	-	1239 (1184-1309)	2637 (2384-3019)	405.09
Number of nematodes per gram of root	90	-	343.00 (281-409)	964.00 (611-754)	93.40

Graph: 2. Pathogenicity of *Pratylenchus thornei* on chickpea pot experiment 1996-97



Graph2A- Pathogenicity of Pratylenchus thornei on chickpea pot experiment 1996-97



(a) Effect on plant growth

(i) Shoot length :

Plant growth parameters viz. shoot length at 30, 60 and 90 DAS, shoot and root weight at 90 DAS were significantly reduced in nematode inoculated plants (T_1) compared to uninoculated control (T_0). Shoot length of plants treated with Carbofuran (T_2) and Phorate (T_3) was significantly increased compared to control (T_1). Shoot length in T_2 and T_3 was not significantly different from each other at 60 and 90 DAS of plant growth, the order being $T_1 < T_0 < T_2 < T_3$ all three stages.

(ii) Shoot weight :

The shoot weight at 90 DAS was significantly more in all nematicide treatments viz. T_2 and T_3 compared to T_1; being in the order $T_1 < T_0 < T_2 < T_3$, the chemical treatments were not significantly different from each other.

(iii) Root weight :

Root weight at 90 DAS was significantly increased in treatments T_2 and T_3 compared to T_1; the order of root weight was $T_1 < T_0 < T_2 < T_3$. The root weight in T_1 and T_0 treatments was not significantly different from each other.

(b) Effect on nematode population :

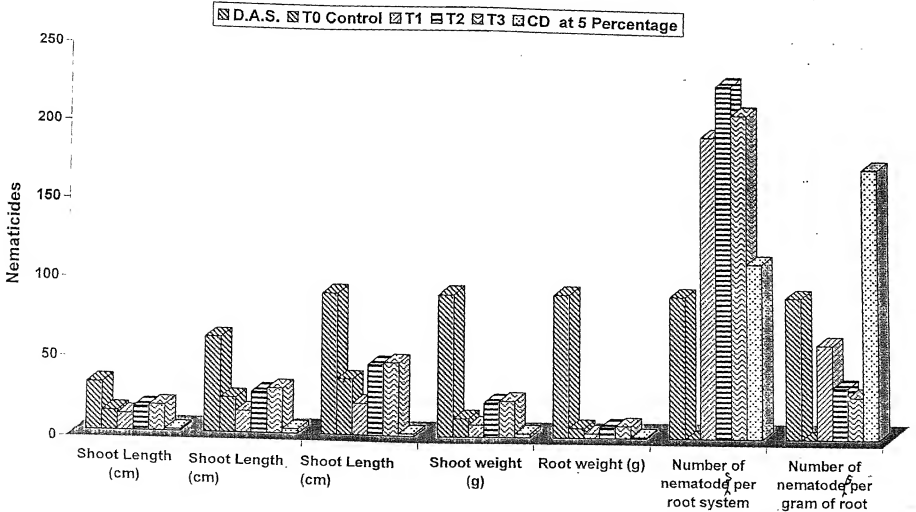
(i) Nematode population per root system :

Treatments T_2 and T_3 significantly reduced root population of nematode compared to untreated nematode inoculated plant T_1; the population being in the order $T_3 < T_2 < T_1$ with no significant difference in population between T_2 and T_3.

Table 3. Evaluation of Nematicides against *Pratylenchus thornei* (Pot experiment) 1996-97

Observation	D.A.S.	Control T_0	1000 Nematodes T_1	1000 Carbofuran T_2	1000 Phorate T_3	CD at 5%
Shoot Length (cm)	30	12.57 (11.2-13.7)	10.8 (10.5-11.0)	15.3 (14.5-15.8)	16.57 (15.8-17.2)	1.16
	60	22.07 (20.9-23.3)	13.8 (13.4-14.2)	26.13 (23.-28.6)	28.50 (26.2-30.0)	2.99
	90	35.53 (34.6-36.2)	20.3 (18.2-22.4)	44.93 (42.3-46.9)	46.27 (44.9-47.0)	1.76
Shoot weight (g)	90	11.8 (10.9-12.6)	7.87 (7.5-8.2)	21.87 (19.9-23.5)	22.83 (19.9-25.4)	2.3
Root weight (g)	90	6.13 (5.3-6.9)	2.9 (2.2-3.6)	6.8 (6.2-7.3)	7.6 (7.2-8.0)	0.71
Number of nematodes per root system	90	-	1912.66 (1785-1985)	226.67 (195-260)	207.67 (179-225)	111.67
Number of nematodes per gram of root	90	-	680 (551-811)	32.67 (30.0-37.0)	27 (24.0-29.0)	173.5

Graph: 3. Evaluation of Nematicides against *Pratylenchus thornei* (Pot experiment) 1996-97



(ii) Nematode population per gram of root :

Carbofuran and Phorate treated plants possessed significantly less nematode per gram of root compared to T_1. The order of nematode population recorded was $T_3<T_2<T_1$. The two chemical treatments not being significantly different from each other.

3. Evaluation of oil cakes against *P. thornei* (Pot experiment) :

The results on effect of four oil cakes viz. Neem (T_2), Mahua (T_3), mustard (T_4) and linseed (T_5) on plant growth and nematode population are included (Table 4), Graph-4,4A.

a. Effect on plant growth :

At 30 DAS, all oil cake treated plants showed significant increase in shoot length compared to untreated nematode inoculated plants, the order of shoot length being T_1 (nematode at one) < T_4 (mustard) < T_3 (Mahua) < T_5 (linseed) < T_2 (Neem) with no significant difference between T4, T3, and T_5 which in turn were significantly less than T_2. Shoot length at 60 DAS, was in the order $T_1 < T_4 < T_3 < T_2 < T_5$; shoot length in treatments T_2, T_3, T_4, T_5 were significantly more than T_1.

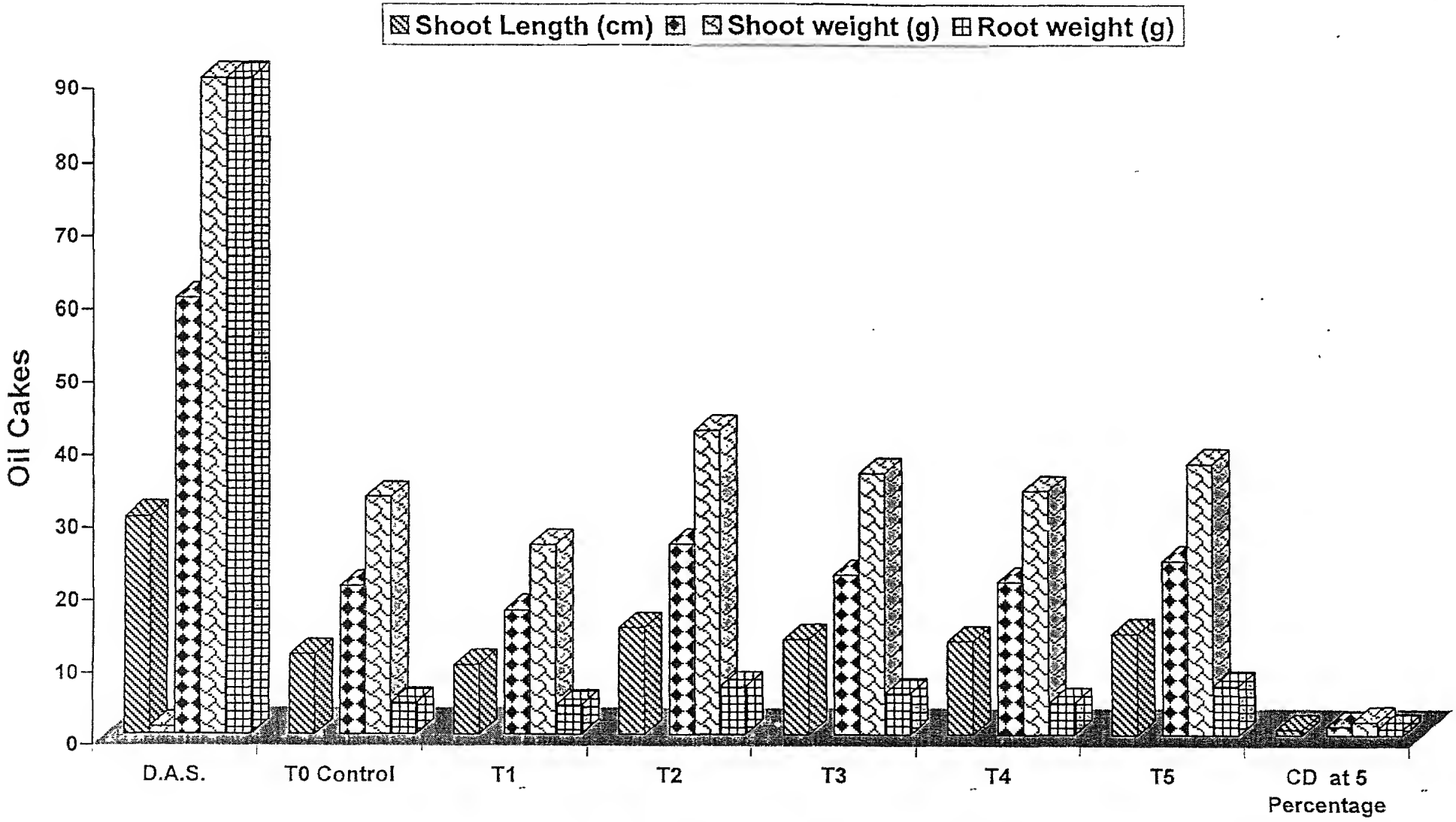
(i) Shoot length

Shoot length in plants amended with mustard, Mahua, Neem and linseed oil cakes was significantly increased compared to nematode inoculated untreated plants

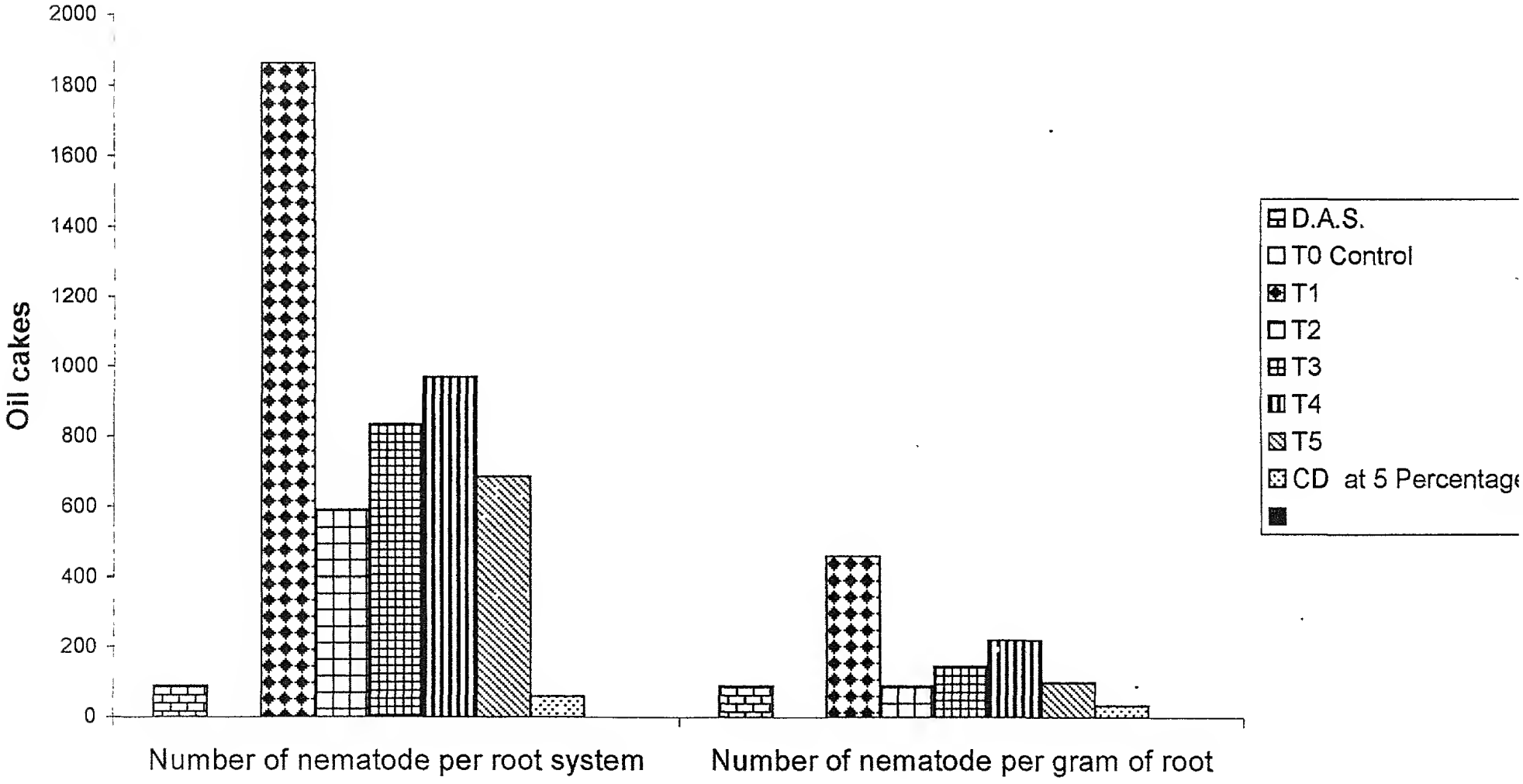
Table 4. Evaluation of four oil cakes against *Pratylenchus thornei* on chickpea, (Pot experiment) 1996-97

Observation	D.A.S.	Control T_0	1000 Nematodes T_1	1000 Nematodes Neem T_2	1000 Nematodes Mahua T_3	1000 Nematodes Mustard T_4	1000 Nematodes Linseed T_5	CD at 5%
Shoot length (cm)	30	11.10 (10.5-11.6)	9.63 (8.9-10.2)	14.80 (14.3-15.2)	13.20 (12.9-13.5)	12.93 (12.6-13.4)	14.03 (13.9-14.0)	0.81
	60	20.50 (9.8-21.2)	17.17 (16.7-17.9)	26.23 (25.8-26.9)	22.00 (20.8-23.0)	21.00 (20.6-21.5)	24.00 (23.8-24.0)	1.29
	90	32.73 (31.8-33.5)	26.17 (25.4-26.9)	41.93 (40.8-43.2)	36.03 (35.0-36.9)	33.57 (32.8-34.0)	37.43 (35.6-38.7)	1.89
Shoot weight (g)	90	11.17 (10.8-11.7)	7.13 (6.50-7.90)	19.57 (19.0-20.0)	14.53 (13.9-15.4)	13.23 (12.9-13.8)	16.33 (15.9-16.8)	0.91
Root weight (g)	90	4.33 (3.8-4.9)	4.07 (3.8-4.3)	6.60 (6.0-7.3)	5.73 (5.3-6.0)	4.43 (3.9-4.9)	6.80 (6.5-7.0)	0.92
Number of nematodes per root system	90	-	1861.3 (1792-1925)	592.3 (560-625)	833.3 (790-890)	968.3 (925-1020)	686.3 (640-720)	59.7
Number of nematodes per gram of root	90	-	457.67 (4.55-471)	90.0 (76.0-98.0)	145.0 (138-149)	220.67 (188-261)	100.3 (98-104)	34.1

Graph 4. Evaluation of four oil cakes against *Pratylenchus thornei* on chickpea, Pot experiment 1996-97



Graph-4A. Evaluation of four oil cakes against *Pratylenchus thornei* on chickpea, Pot experiment 1996-97



at 90 DAS, being in the order T_1, $T_0 < T_4 < T_3 < T_5 < T_2$ with significant difference between treatment except T_0 and T_4.

(ii) Shoot weight :

Shoot weight at DAS was significantly increased in all oil cake treatments compared to untreated nematode inoculated plants. The order being – $T_1 < T_0 < T_4 < T_3 < T_5 < T_2$.

(iii) Root weight :

Root weight at 90 DAS in all oil cakes treatments was significantly increased compared T_1 (nematode alone), with no significant difference between T_0 (unoculated nematode), T_4 (mustard), T_3 (Mahua), T_2 (Neem), T_5 (linseed); The order of root weight being $T_1 < T_0 < T_4 < T_3 < T_2 < T_5$.

b. Effect on nematode population :

(i) Nematode population per root system :

All the four oil cakes (Neem, Mahua, linseed, mustard) significantly decreased root population of *P. thornei* compared to T_1 at 90 DAS; The order being $T_1 > T_4 > T_3 > T_5 > T_2$; with significantly reduced number of nematodes per root system in T_2 compared to T_5, T_3 and T_4; with T_5 and T_3 being not significantly different from one another and having significantly less population than T_4.

(ii) Nematode population per gram of root :

At 90 DAS, the number of nematodes per gram of root in all the four oil cake treatments was significantly reduced compared to T_1, the order of nematode population being $T_1 > T_4 > T_3 > T_5 > T_2$. There was no significant difference in

nematode population per gram of root in treatments T_2, T_5 and T_3, T_4; with significantly less number of nematodes in T_2 compared to T_5, T_3 and T_4. Application of T_3 (Mahua), T_2 (Neem), T_5 (linseed), caused significantly more reduction in nematode population compared to mustard (T_4).

4. Management of *Pratylenchus thornei* on chickpea with nematicides (Field experiment)

A. Shoot length in cm per plant

Year 1996-97 (Table 5a)

a.1. Effect of treatment :

The data represent show that the shoot length in Phorate (32.25 cm) and in Carbofuran (32.75 cm) was not significantly different from each other but significantly less than control (33.75 cm).

a.2. Effect of DAS

The shoot length Significant difference in shoot length was recorded after 45 DAS and 105 DAS; The shoot length being 19.33, 37.29 and 42.12 cm respectively.

Year 1997-98 (Table 5b) Graph-5

b.1 Effect of treatment

The data on shoot length represents that there was no significant difference in shoot length in Carbofuran and Phorate as also from control.

b.2 Effect of DAS

The shoot length increased significantly at 45 DAS, 75 DAS and 105 DAS on chickpea with significant difference on each day.

B. Shoot weight in gm (two plant)

Year 1995-1996 (Table 6a) Graph-6

a.1. Effect of treatment:

The observations show that the shoot weight was in the order – control (18.22) < Carbofuran (22.70) < Phorate (30.62); with control and Carbofuran and Carbofuran and Phorate not significantly different from each other.

Table 5 Management of *Pratylenchus thornei* on chickpea with nematicides: (Field experiment) Shoot Length (cm)

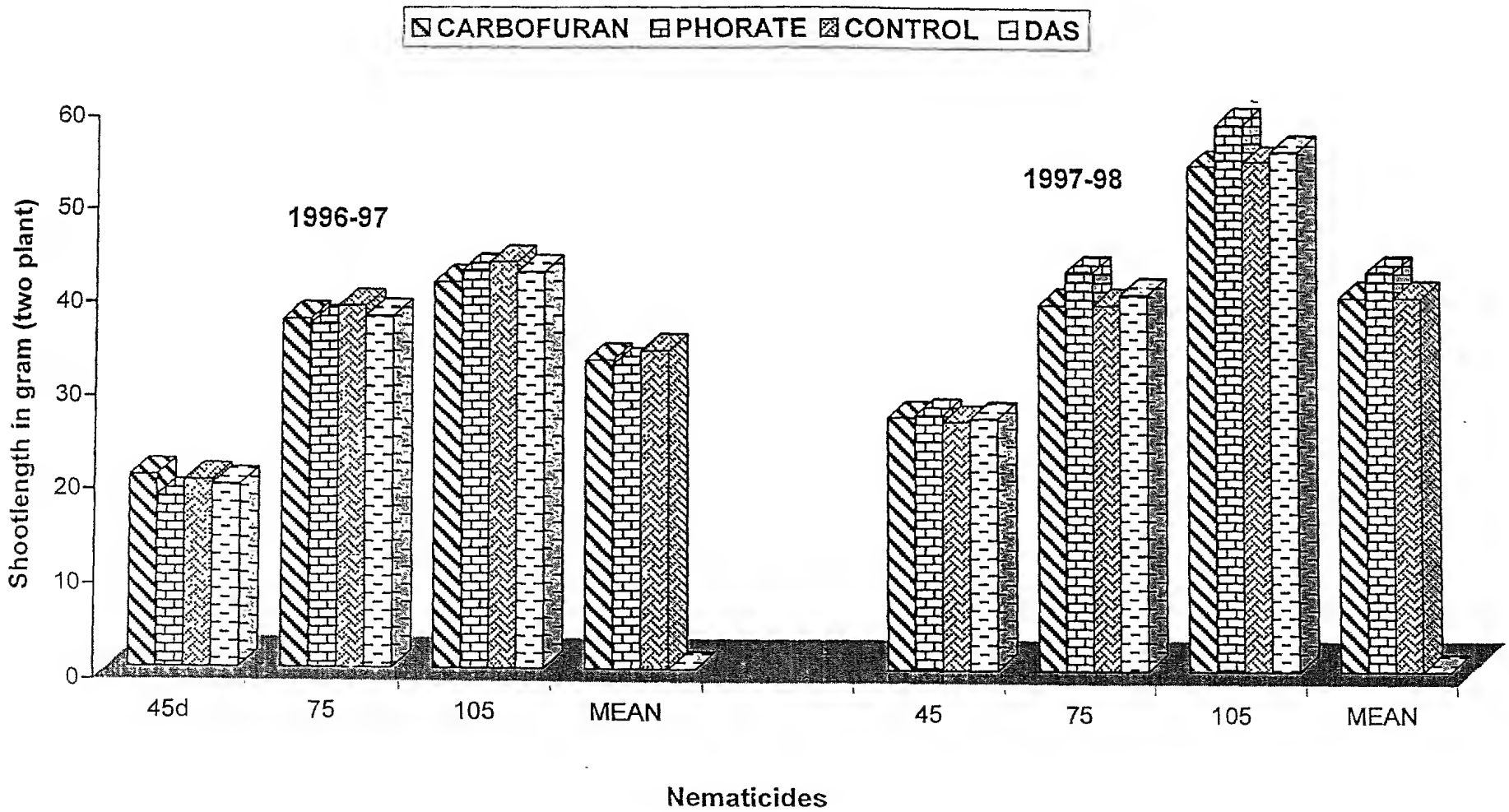
Table No 5a 1996-97 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	20.25	37.00	41.00	32.75
PHORATE	18.00	36.50	42.25	32.25
CONTROL	19.75	38.38	43.13	33.75
DAS	19.33	37.29	42.12	
C.D. DAS at 5%	0.6439			
C.D. Treatment at 5% :	0.6439			

Table No 5b 1997-98 Four repiicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	26.75	38.75	53.75	39.75
PHORATE	27.00	42.25	58.25	42.50
CONTROL	26.25	38.75	54.25	39.75
DAS	26.66	39.91	55.41	
C.D. DAS at 5%	3.2244			
C.D. Treatment at 5% :	NS			

Graph: 5. Management of *Pratylenchus thornei* on chickpea with nematicides shoot length in gram (two plant) Field experiment.



a.2. Effect of DAS

Significantly more shoot weight was recorded after 90 DAS as compared 45 DAS. The shoot weight being 6.72 and 40.97, respectively.

Year 1996-97 (Table 6b)

b.1. Effect of treatment

The observations show that the shoot weight was in the order – control (29.25) < Carbofuran (33.08) < Phorate (39.50), with control and Carbofuran and Carbofuran and Phorate not significantly different from each other.

b.2 Effect of DAS

The shoot weight was in the order 45 DAS < 75 DAS < 105 DAS on chickpea with significant difference on each day.

Year 1997-98 (Table 6c)

c.1 The data on shoot weight represents that there was no significant difference in shoot weight in control and Carbofuran as also from Phorate.

c.2 Effect of DAS

The shoot weight increased significantly at 45 DAS, 75 DAS and 105 DAS on chickpea with significantly difference on each day.

C. Root weight in gm (two plant)

Year 1995-96 (Table 7a) Graph-7

a.1 Effect of treatments :

The observations show that the root weight was not significantly different in control and Carbofuran as also from Phorate.

a.2 Effect of DAS

Significantly more root weight was recorded after 90 DAS compared to 45 DAS, the root weight being 3.54 and 2.63, respectively.

Table 6 Management of *Pratylenchus thornei* on chickpea with nematicides: Shoot weight in gm (two plant).

Table No 6a 1995-96 Three replicates

NEMATICIDE	45das	90 das	MEAN
CARBOFURAN	6.23	39.17	22.70
PHORATE	6.80	54.43	30.62
CONTROL	7.13	29.30	18.22
DAS	6.72	4.97	

C.D. DAS at 5% 9.4982

C.D. Treatment at 5% : 11.6328

Table No 6b 1996-97 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	21.25	31.50	46.50	33.08
PHORATE	24.50	37.00	57.25	39.58
CONTROL	22.00	30.00	35.75	29.25
DAS	22.58	32.83	46.50	

C.D. DAS at 5% 8.6283

C.D. Treatment at 5% : 8.6283

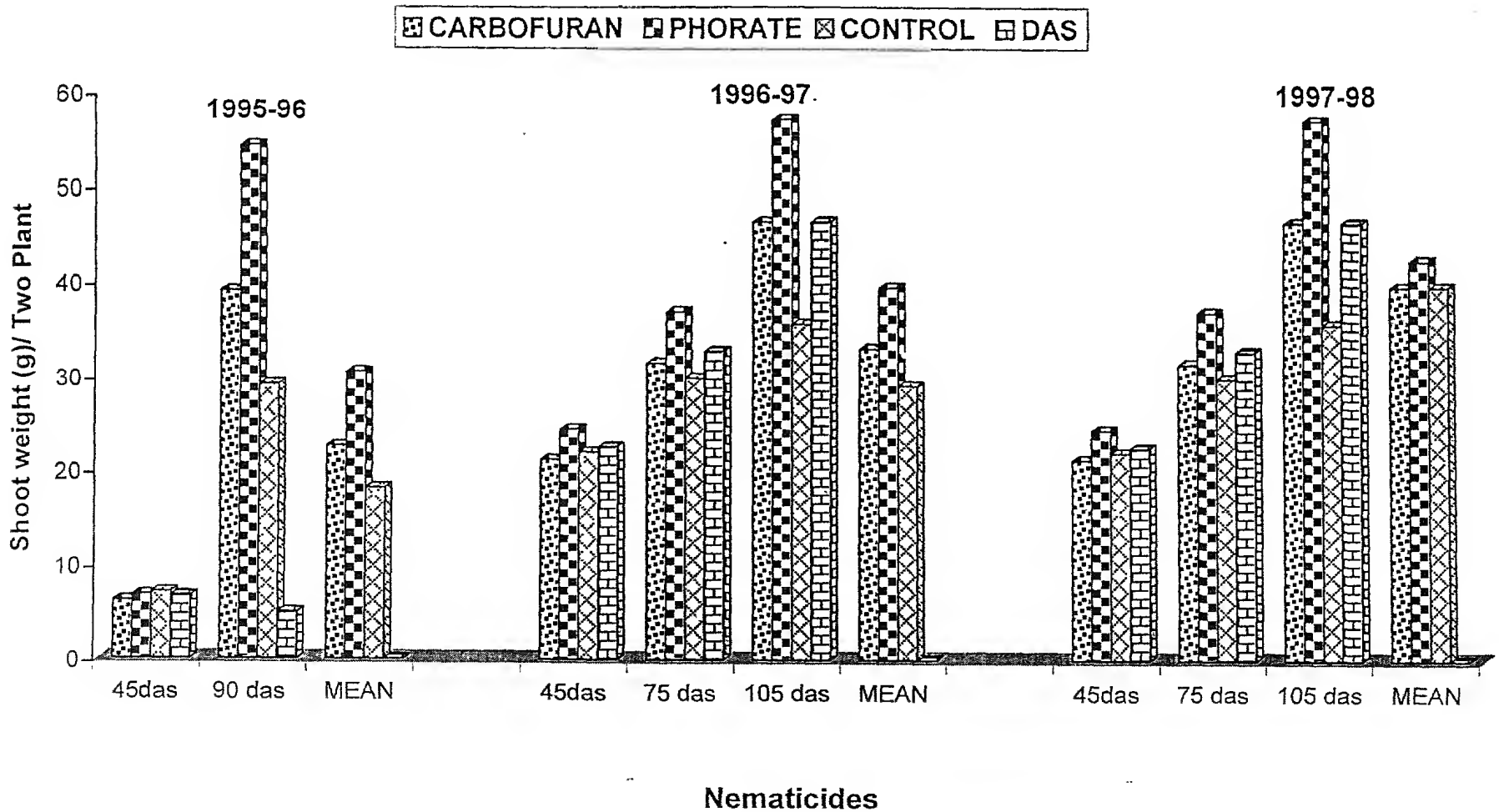
Table No 6c 1997-98 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	21.25	31.50	46.50	39.75
PHORATE	24.50	37.00	57.25	42.50
CONTROL	22.00	30.00	35.75	39.75
DAS	22.58	32.83	46.50	

C.D. DAS at 5% 3.3856

C.D. Treatment at 5% : NS

Graph: 6. Management of *Pratylenchus thornei* on chickpea with nematicides Shoot weight in gm (two plant).



Year 1996-97 (Table 7b)

b.1. Effect of treatments :

The observations show that the root weight in Phorate (3.93 gm) and Carbofuran (3.93 gm) was not significantly different from each other and was significantly more compared to control (3.08 gm).

b.2 Effect of DAS :

Root weight was recorded in the order – 45 DAS < 105 DAS < 75 DAS on chickpea, with significant difference from each other.

Year 1997-98 (Table 7c)

c.1 Effect of treatments :

The data on root weight represents that there was no significant difference in root weight in control and Carbofuran as also from Phorate.

c.2 Effect of DAS :

Significantly more root weight was recorded after 75 DAS compared to 45 DAS and 105 DAS. The root weight was in the order – 45 DAS < 105 DAS < 75 DAS.

D. Nematode population in 500 gm soil

Year 1995-96 (Table 8a) Graph-8

a.1. Effect of treatments :

The observations show that the nematode population in Carbofuran (9.50) and in Phorate (10.67) was not significantly different from each other and was significantly less compared to control (22.00).

Table 7 Management of *Pratylenchus thornei* on chickpea with nematicides: Root weight in gm (two plant).

Table No 7a 1995-96 Three replicates

NEMATICIDE	45das	90 das	MEAN
CARBOFURAN	2.80	3.47	3.13
PHORATE	2.60	3.70	3.15
CONTROL	2.50	3.47	2.98
DAS	2.63	3.54	

C.D. DAS at 5% 0.4905

C.D. Treatment at 5% : 0.6008

Table No 7b 1996-97 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	3.00	5.15	3.63	3.93
PHORATE	2.05	5.68	4.08	3.93
CONTROL	2.58	2.88	3.78	3.08
DAS	2.54	4.57	3.83	

C.D. DAS at 5% 0.6439

C.D. Treatment at 5% : 0.6439

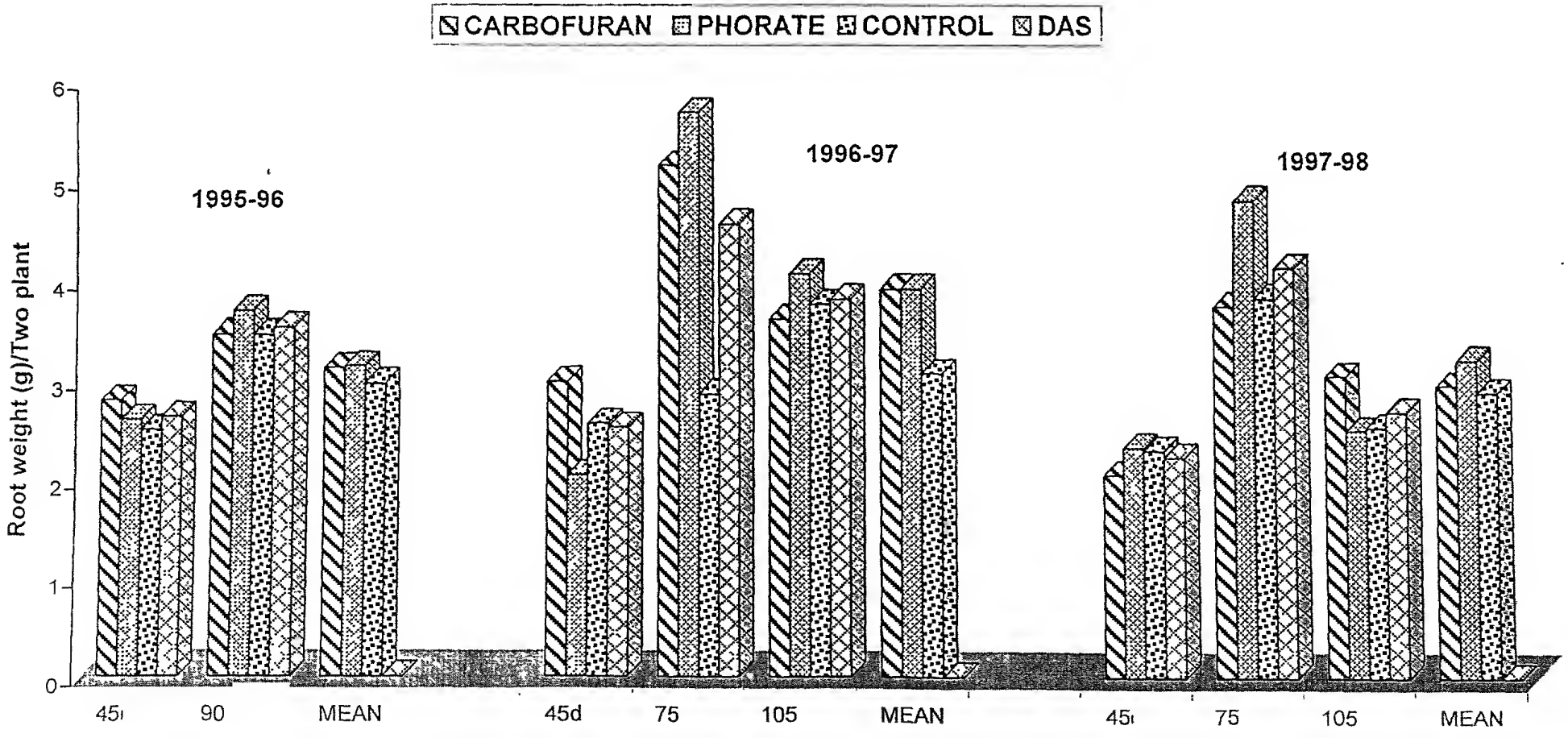
Table No 7c 1997-98 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	2.05	3.75	3.05	2.95
PHORATE	2.33	4.80	2.50	3.21
CONTROL	2.30	3.83	2.53	2.88
DAS	2.23	4.13	2.69	

C.D. DAS at 5% 0.7601

C.D. Treatment at 5% : NS

Graph: 7. Management of *Pratylenchus thornei* on chickpea with nematicides Root weight in gm (two plant).



a.2. Effect of DAS :

Significant more nematode population was recorded after 90 DAS compared to 45 DAS. The nematode population being 11.75 and 16.33, respectively.

Year 1996-97 (Table 8b)

b.1 Effect of treatments :

The data show that the nematode population in Carbofuran (11.13) and in Phorate (13.75) was not significantly different from each other and was significantly less compared to control (39.19).

b.2 Effect of DAS :

Significantly more nematode population was recorded after 120 DAS compared to 60 DAS, 90 DAS and 30 DAS which in turn were non significantly different from each other. The nematode population was recorded in the order 60 DAS < 90 DAS < 30 DAS < 120 DAS.

Year 1997-98 (Table 8c)

c.1 Effect of treatments :

The observations show that the nematode population was in the order – Carbofuran (22.56) < Phorate (27.31), control (36.06); with Carbofuran and Phorate and Phorate and control not significantly different from each other.

c.2 Effect of DAS :

The nematode population was in the order 30 DAS < 120 DAS < 60 DAS < 90 DAS; with 60 and 120 DAS not being significantly different from each other.

Table 8 Management of *Pratylenchus thornei* on chickpea with nematicides: Nematode population in 500gm soil.

Table No 8a 1995-96 Three replicates

NEMATICIDE	45das	90 das	MEAN
CARBOFURAN	8.00	11.00	9.50
PHORATE	9.67	11.67	10.67
CONTROL	17.67	26.33	22.00
DAS	11.78	16.33	

C.D. DAS at 5% 2.2583

C.D. Treatment at 5% : 2.7658

Table No 8b 1996-97 Four replicates

NEMATICIDE	30 das	60das	90das	120das	MEAN
CARBOFURAN	15.75	5.25	9.50	14.00	11.13
PHORATE	15.50	6.00	11.25	22.25	13.75
CONTROL	28.00	31.50	23.75	73.50	39.19
DAS	19.75	14.25	14.83	36.58	

C.D. DAS at 5% 8.8056

C.D. Treatment at 5% : 7.6259

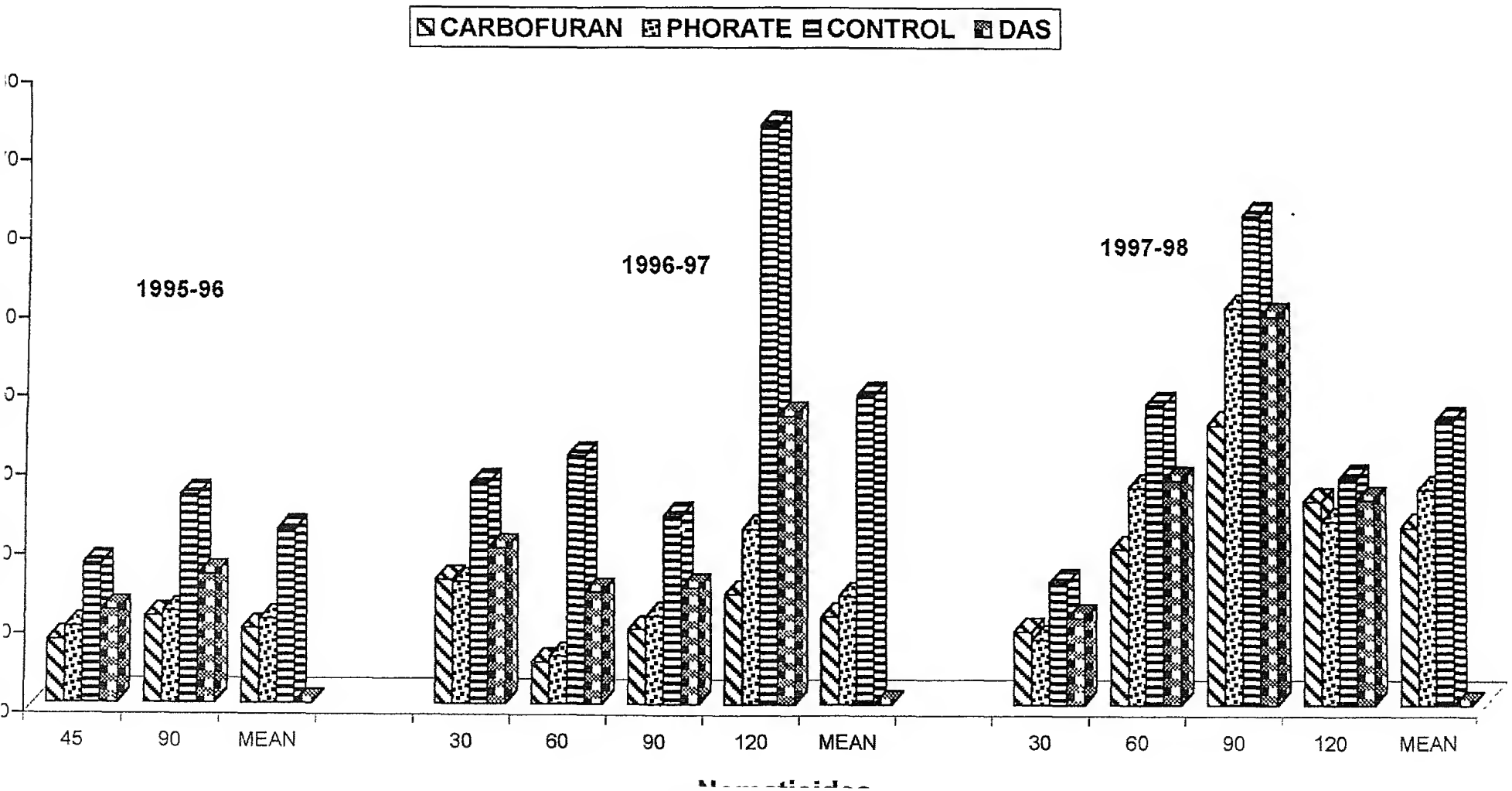
Table No 8c 1997-98 Four replicates

NEMATICIDE	30 das	60das	90das	120das	MEAN
CARBOFURAN	9.25	19.75	35.50	25.75	22.56
PHORATE	8.25	27.50	50.25	23.25	27.31
CONTROL	15.50	38.00	62.00	28.75	36.06
DAS	11.00	28.42	49.25	25.92	

C.D. DAS at 5% 11.6670

C.D. Treatment at 5% : 10.1039

Graph: 8. Management of *Pratylenchus thornei* on chickpea with nematicides Nematode population in 500gm soil.



E. Nematode population per gm of root

Year 1995-96 (Table 9a) Graph-9

a.1 Effect of treatments :

The observations show that the nematode population per gm of root in Carbofuran (2.83) and Phorate (3.33) was not significantly different from each other was significantly less compared to control (8.17).

a.2 Effect of DAS :

Significantly more nematode population was recorded after 90 DAS compared to 45 DAS; the nematode population being 3.44 and 6.11 respectively.

Year 1996-97 (Table 9b)

b.1 Effect of treatments :

The data shows that the nematode population in Carbofuran (12.17) and Phorate (14.75) which was not significantly different was significantly less from control (21.17); the order being – Carbofuran < Phorate < Control.

b.2 Effect of DAS :

The nematode population was recorded in the order – 75 DAS < 45 DAS with population at 45 DAS not significantly different from 105 DAS.

Year 1997-98 (Table 9c)

c.1 Effect of treatments :

The observation show that the nematode population per gm of root in Phorate (2.00) and Carbofuran (3.00) was not significantly different from each other and was significantly less compared to control (12.50).

Table 9 Management of *Pratylenchus thornei* on chickpea due to nematicides: Nematode population per gm of root system.

Table No 9a 1995-96 Three replicates

NEMATICIDE	45das	90 das	MEAN
CARBOFURAN	1.33	4.33	2.83
PHORATE	1.67	5.00	3.33
CONTROL	7.33	9.00	8.17
DAS	3.44	6.11	
C.D. DAS at 5%	0.8841		
C.D. Treatment at 5% :	1.0428		

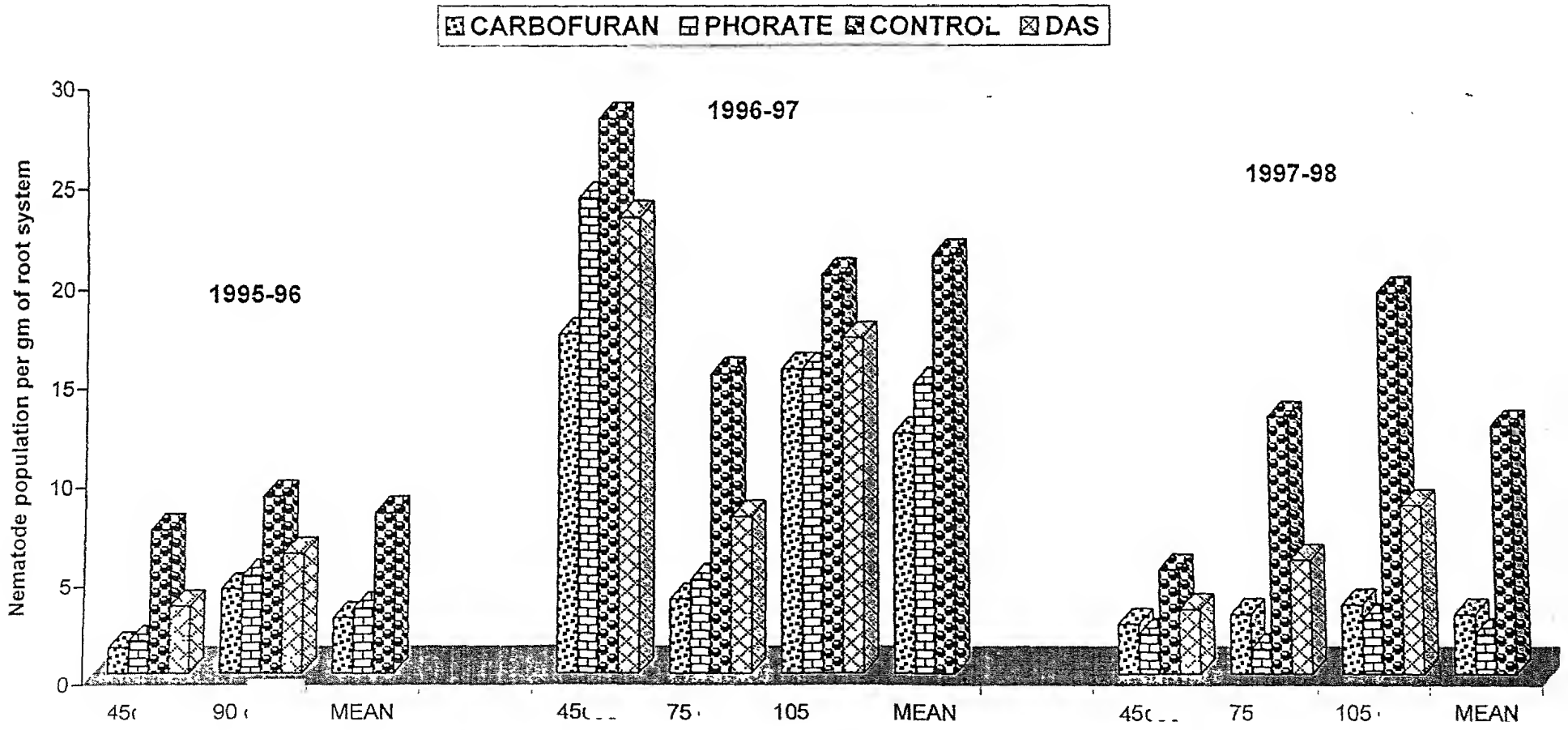
Table No 9b 1996-97 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	17.25	3.75	15.50	12.17
PHORATE	24.00	4.75	15.50	14.75
CONTROL	28.00	15.25	20.25	21.17
DAS	23.08	7.92	17.08	
C.D. DAS at 5%	6.2688			
C.D. Treatment at 5% :	6.2688			

Table No 9c 1997-98 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	2.50	3.00	3.50	3.00
PHORATE	2.00	1.25	2.75	2.00
CONTROL	5.25	13.00	19.25	12.50
DAS	3.25	5.75	8.50	
C.D. DAS at 5%	2.6695			
C.D. Treatment at 5% :	2.6695			

Graph: 9 Management of *Pratylenchus thornei* on chickpea due to nematicides; Nematode population per gm of root system.



c.2 Effect of DAS :

Significantly more nematode population per gm of root was recorded after 105 DAS compared to 45 DAS and 75 DAS; with the latter two not significantly different from each other. The nematode population was in the order 45 DAS < 75 DAS < 105 DAS.

F. Number of nodules (two plant)

Year 1995-96 (Table 10a) Graph-10

a.1 Effect of treatments :

The data show that the number of nodules in Phorate was significantly more compared to control and Carbofuran, which in turn were not significantly different from each other.

a.2 Effect of DAS

Number of nodules was not significant different from each other on 45 and 90 DAS.

Year 1996-97 (Table 10b)

b.1 Effect of treatments :

The data represents show that the number of nodules in Phorate (46.00) and Carbofuran (49.00) was not significantly different from each other and was significantly more compared to control (33.00).

b.2 Effect of DAS :

The number of nodules was not increased significantly different at 45, 75 and 105 DAS.

Year 1997-98 (Table 10c)

c.1 Effect of treatments :

The data on number of nodules show that there was no significant difference in number of nodules in Carbofuran and Phorate as also from control.

Table 10 Management of *Pratylenchus thornei* on chickpea with nematicides: Number of nodules (two plant).

Table No 10a 1995-96 Three replicates

NEMATICIDE	45das	90 das	MEAN
CARBOFURAN	54.00	65.00	60.00
PHORATE	69.00	77.00	73.00
CONTROL	56.00	60.00	58.00
DAS	60.00	67.00	

C.D. DAS at 5% NS

C.D. Treatment at 5% : 11.4550

Table No 10b 1996-97 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	45.00	55.00	46.00	49.00
PHORATE	36.00	50.00	52.00	46.00
CONTROL	36.00	29.00	35.00	33.00
DAS	36.00	45.00	45.00	

C.D. DAS at 5% NS

C.D. Treatment at 5% : 6.2711

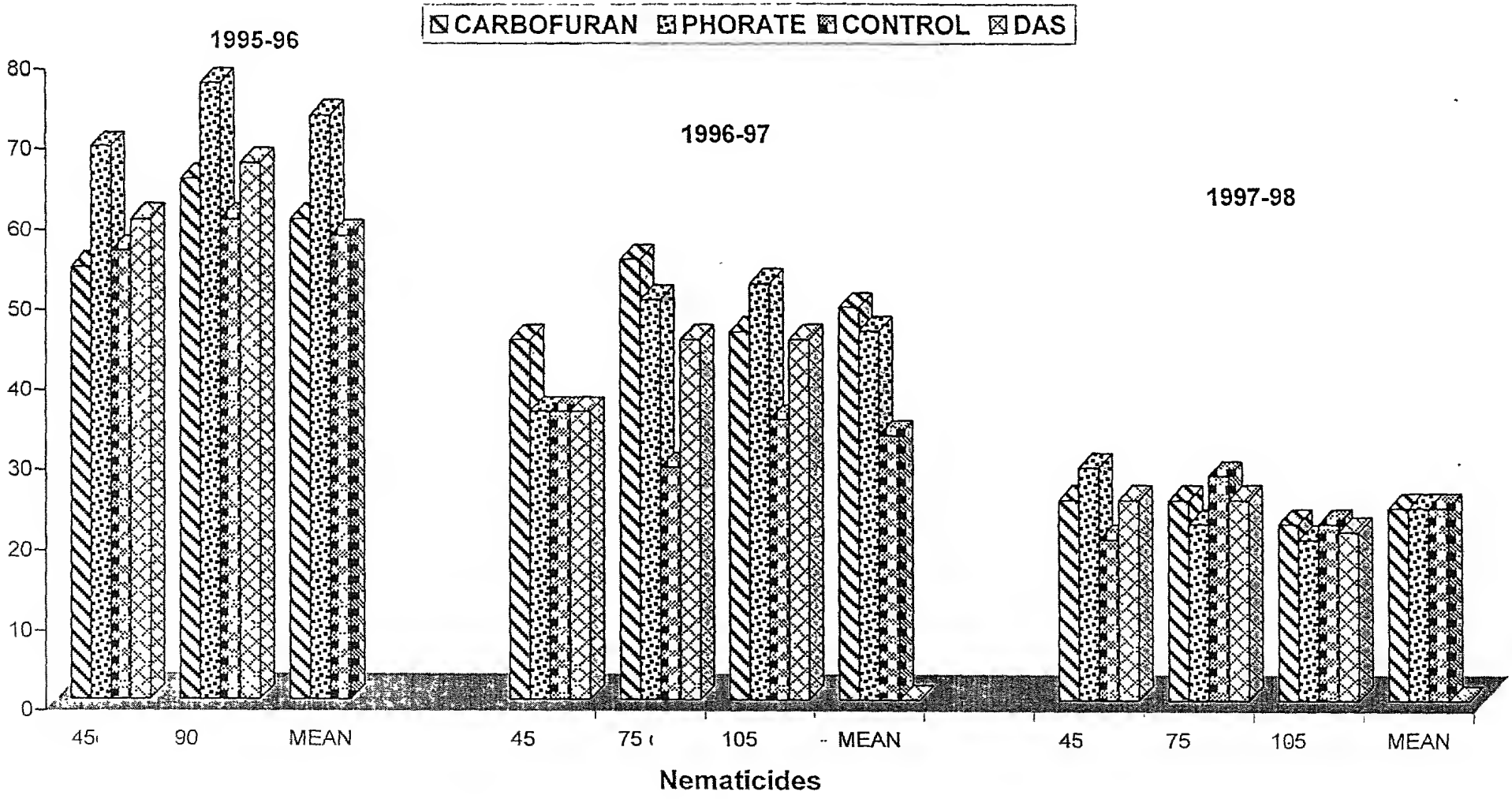
Table No 10c 1997-98 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	25.00	25.00	22.00	24.00
PHORATE	29.00	22.00	20.00	24.00
CONTROL	20.00	28.00	22.00	24.00
DAS	25.00	25.00	21.00	

C.D. DAS at 5% NS

C.D. Treatment at 5% : NS

Graph: 10. Management of *Pratylenchus thornei* on chickpea with nematicides Number of nodules (two plant).



c.2 Effect of DAS:

The number of nodules was not increased significantly different at 105, 75 and 45 DAS.

G. Weight of 10 nodules in mg

Year 1995-97 (Table 11a) Graph-11

a.1 Effect of treatments :

The observations show that the weight of 10 nodules in mg was in the order – control < Carbofuran < Phorate.

a.2 Effect of DAS :

The mean weight per 10 nodules at 45 DAS was recorded as 2.51 mg.

Year 1996-97 (Table 11b)

b.1 Effect of treatments :

The data on weight of 10 nodules in mg shows that there was no significant difference in weight of 10 nodules in Phorate and Carbofuran, which in turn was significantly more than control.

b.2 Effect of DAS :

Significantly weight of 10 nodules in mg was recorded after 75DAS, 105 DAS compared to 45 DAS and 105 with no significantly difference from each other, The weight of 10 nodules in mg was in the order 105 DAS < 45 DAS < 75 DAS.

Year 1997-98 (Table 11c)

c.1 Effect of treatments :

The data on weight of 10 nodules in mg show that there was no significant difference in weight of 10 nodules in mg in Phorate and Carbofuran which was less compared to control.

Table 11 Management of *Pratylenchus thornei* on chickpea due to nematicides: Weight of 10 nodules in mg.

Table No 11a 1995-96 Three replicates

NEMATICIDE	45das
CARBOFURAN	267
PHORATE	278
CONTROL	210
DAS	251

Table No 11b 1996-97 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	355	560	232	382
PHORATE	312	480	335	376
CONTROL	341	293	244	293
DAS	336	444	270	

C.D. DAS at 5% 117.0585

C.D. Treatment at 5% : NS

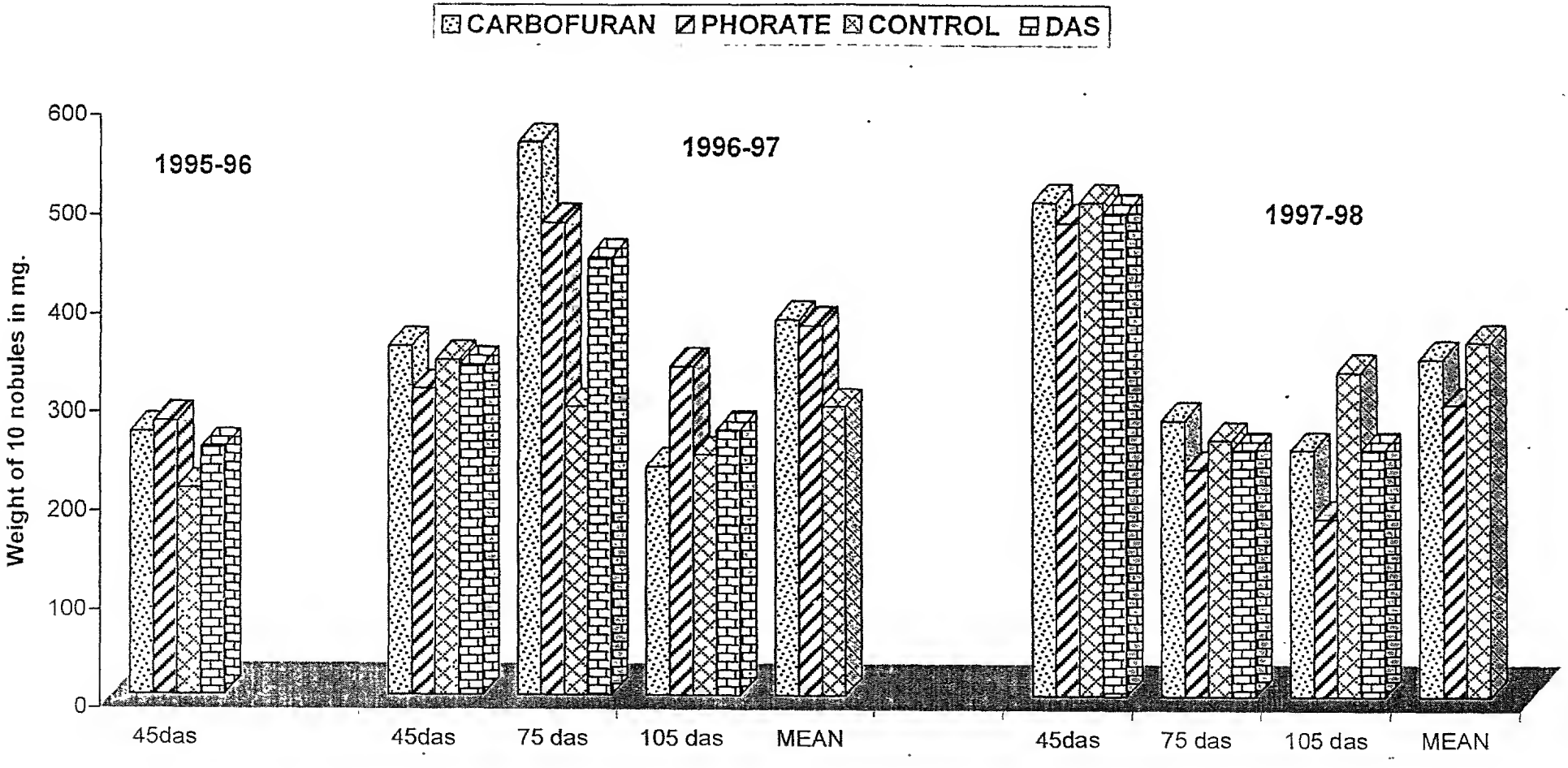
Table No 11c 1997-98 Four replicates

NEMATICIDE	45das	75 das	105 das	MEAN
CARBOFURAN	500	280	250	343
PHORATE	480	230	180	296
CONTROL	500	260	330	360
DAS	490	250	250	

C.D. DAS at 5% 9.590

C.D. Treatment at 5% : NS

Graph: 11. Management of *Pratylenchus thornei* on chickpea due to nematicides Weight of 10 nodules in mg.



c.2 Effect of DAS :

The weight at 45 DAS was significantly more compared to 75 DAS and 105 DAS, which in turn were not significantly different from each other. The weight of 10 nodules was in the order 75 DAS = 105 DAS < 45 DAS.

5. Management of *Pratylenchus thornei* on chickpea with oil cakes (Field experiment):

A. Shoot length per plant in cm

Year 1996-97 (Table 12a) Graph-12

a.1 Effect of treatment :

The data on shoot length represents that there was no significant difference in shoot length in Neem, Mahua, mustard and control as also from linseed. The order was - Neem < Mahua < mustard < control < linseed.

a.2 Effect of DAS :

Shoot length was recorded in the order – 45 DAS < 75 DAS < 105 DAS of chickpea; with significant difference from each other.

Year 1997-98 (Table 12b)

b.1 Effect of treatments :

The data on shoot length represent that there was no significant difference in shoot length in control, Neem, mustard and Mahua as also from linseed. The order was - control < Neem < mustard < Mahua < linseed.

Table 12 Management of *Pratylenchus thornei* on chickpea due to Oil cake: Shoot Length per plant in cm.

Table No 12a 1996-97 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	18.00	35.50	37.50	30.33
MAHUA	20.25	34.50	44.00	32.92
LINSEED	20.25	36.25	45.75	34.08
MUSTARD	19.75	35.75	44.75	33.42
CONTROL	19.75	38.38	43.13	33.75
DAS	19.60	36.08	43.03	

C.D. DAS at 5% 2.1502

C.D. Treatment at 5% : NS

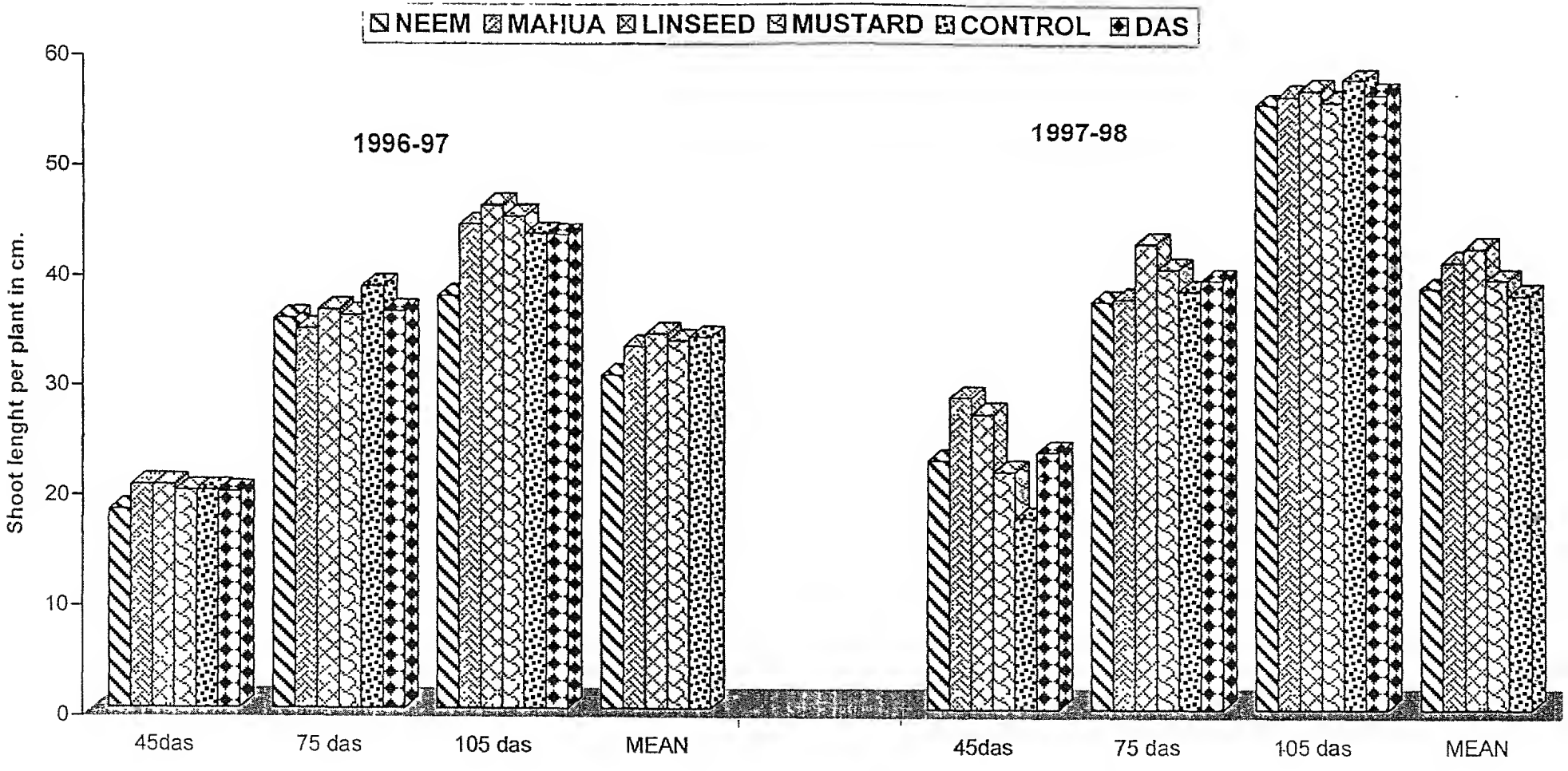
Table No 12b 1997-98 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	22.50	37.00	55.00	38.17
MAHUA	28.25	37.25	55.75	40.58
LINSEED	26.75	42.25	56.25	41.75
MUSTARD	21.50	40.00	55.25	38.92
CONTROL	17.25	38.00	57.25	37.50
DAS	23.25	39.00	55.90	

C.D. DAS at 5% 3.4075

C.D. Treatment at 5% : NS

Graph: 12. Management of *Pratylenchus thornei* on chickpea due to Oil cake. Shoot Length per plant in cm.



b.2 Effect of DAS :

Shoot length was recorded in the order – 45 DAS < 75 DAS < 105 DAS of chickpea with significant difference from each other.

B. Shoot weight in gm two plants :

Year 1995-96 (Table 13a) Graph-13

a.1 Effect of treatments :

The observations show that the shoot weight was in the order – soybean < mustard < linseed < control < Neem; with soybean, mustard, linseed, control; mustard, linseed, control; and linseed, control, Neem were not significantly different from each other.

a.2 Effect of DAS :

Significantly more shoot weight was recorded after 90 DAS compared 45 DAS after sowing, the shoot weight being 6.26 and 26.91, respectively.

Year 1996-97 (Table 13b)

b.1 Effect of treatments :

The observation show that shoot weight in Neem cake (34.47), control (34.55), mustard cake (38.38) and Mahua cake (38.88) was not significantly different from each other and was significantly less compared to linseed cake (41.06).

b.2 Effect of DAS :

Shoot weight was recorded in the order – 45 DAS < 75 DAS < 105 Days after sowing of chickpea; with significant difference from each other at all stages.

Table 13 Management of *Pratylenchus thornei* on chickpea due to Oil cake: Shoot Weight in gm (Two plant)

Table No 13a 1995-96 Three replicates

OIL CAKE	45das	90 das	MEAN
NEEM	5.83	36.20	21.02
SOYABEAN	6.37	18.40	12.38
LINSEED	5.90	27.63	16.77
MUSTARD	6.06	23.03	14.55
CONTROL	7.13	29.30	18.22
DAS	6.26	26.91	

C.D. DAS at 5% 3.8604

C.D. Treatment at 5% : 6.1039

Table No 13b 1996-97 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	13.48	28.45	61.47	34.47
MAHUA	15.50	39.63	61.52	38.88
LINSEED	18.33	41.06	63.80	41.06
MUSTARD	18.93	36.25	57.95	38.38
CONTROL	17.48	27.70	58.46	34.55
DAS	16.74	34.62	61.04	

C.D. DAS at 5% 3.5690

C.D. Treatment at 5% : 4.6075

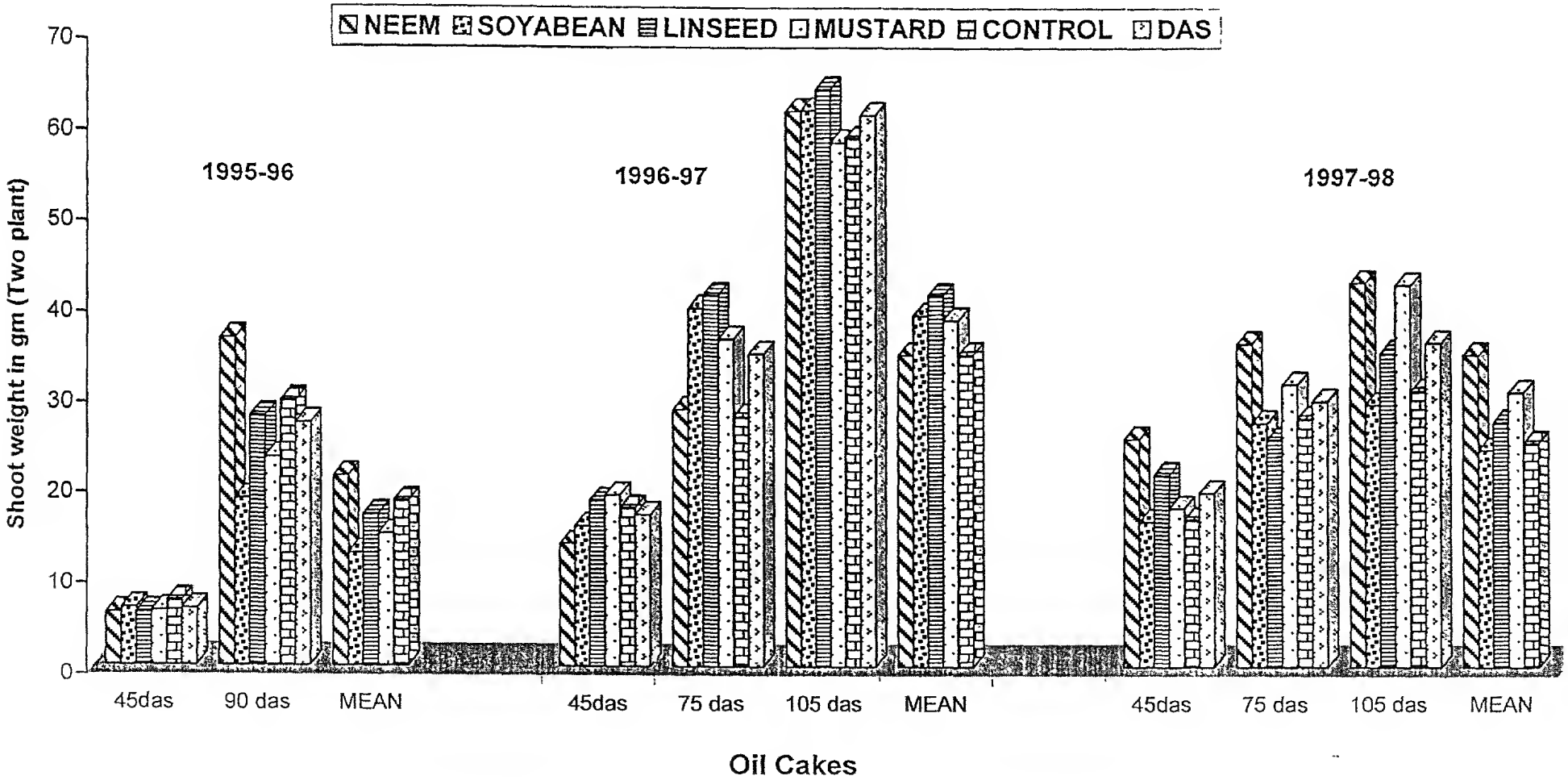
Table No 13c 1997-98 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	25.25	35.75	42.50	34.50
MAHUA	16.00	27.00	29.00	24.00
LINSEED	21.25	25.25	34.75	27.08
MUSTARD	17.50	31.25	42.25	30.33
CONTROL	16.25	27.50	30.50	24.75
DAS	19.25	29.35	35.80	

C.D. DAS at 5% 5.6127

C.D. Treatment at 5% : NS7.2460

Graph: 13. Management of *Pratylenchus thornei* on chickpea due to Oil cake. Shoot Weight in gm (Two plant)



Year 1997-98 (Table 13c)

c.1 Effect of treatments :

The observation show that the shoot weight in Mahua cake (24.00), control (24.75), linseed cake (27.08) and mustard cake (30.33) was not significantly different from each other and was significantly more compared to Neem cake (34.50).

c.2 Effect of DAS :

Shoot weight was recorded in the order – 45 DAS < 75 DAS < 105 Days of sowing of chickpea, with significant difference from each other at all stages.

C. Root weight in gram (two plants)

Year 1995-96 (Table 14a) Graph-14

a.1 Effect of treatments :

The observations show that the root weight was in the order - linseed < mustard < Neem < soybean < control; with linseed, mustard; mustard, Neem, soybean and soybean and control were not significantly different from each other.

a.2 Effect of DAS :

Significantly more root weight was recorded after 90 DAS compared 45 Days after sowing, the root weight being - 2.53 and 1.96, respectively.

Year 1996-97 (Table 14b)

b.1 Effect of treatments :

The observation show that the root weight was significantly higher in linseed (3.61) compared to Mahua, Neem and control; the order was Mahua < Neem < control < mustard < linseed; with Mahua, Neem, control and mustard; mustard and linseed not significantly different from each other.

Table 14 Management of *Pratylenchus thornei* on chickpea due to Oil cake: Root Weight in gm (Two plant)

Table No 14a 1995-96 Three replicates

OIL CAKE	45das	90 das	MEAN
NEEM	1.80	2.77	2.28
SOYABEAN	2.10	2.63	2.37
LINSEED	1.23	1.93	1.58
MUSTARD	2.27	2.40	2.18
CONTROL	2.40	3.47	2.93
DAS	1.96	2.53	

C.D. DAS at 5% 0.3866

C.D. Treatment at 5% : 0.6112

Table No 14b 1996-97 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	3.00	3.10	3.10	3.07
MAHUA	2.18	3.93	2.88	2.99
LINSEED	3.18	4.20	3.53	3.63
MUSTARD	2.63	3.73	3.55	3.30
CONTROL	2.58	2.88	3.78	3.08
DAS	2.71	3.57	3.37	

C.D. DAS at 5% 0.2813

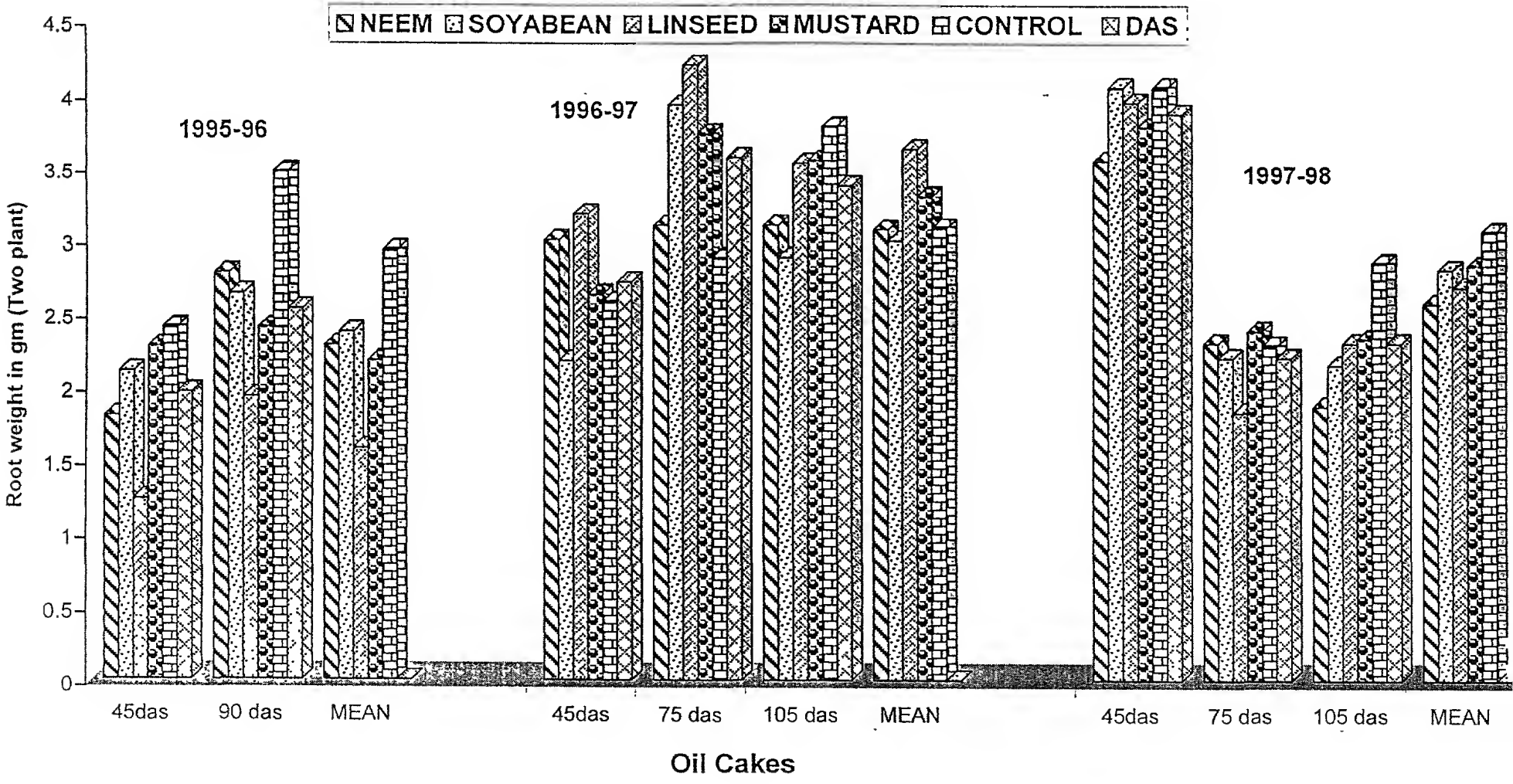
C.D. Treatment at 5% : 0.3632

Table No 14c 1997-98 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	3.55	2.30	1.87	2.57
MAHUA	4.05	2.20	2.15	2.80
LINSEED	3.95	1.83	2.30	2.68
MUSTARD	3.78	2.38	2.33	2.83
CONTROL	4.05	2.28	2.85	3.06
DAS	3.87	2.20	2.30	

C.D. DAS at 5% 0.5425

Graph: 14. Management of *Pratylenchus thornei* on chickpea due to Oil cake. Root Weight in gm (Two plant)



b.2 Effect of DAS :

Significantly more root weight was recorded after 75 DAS and 105 DAS compared to 45 days after sowing; the weight on 75 and 105 DAS was not significant from each other. The root weight at 75, 105 and 45 DAS being 3.57, 3.37 and 2.71 respectively.

Year 1997-98 (Table 14c)

c.1 Effect of treatments :

The data on root weight represents that there was no significant difference in root weight in Neem, linseed, Mahua and mustard as also from control, the order of root weight was - Neem < linseed < Mahua < mustard < control.

c.2 Effect of DAS :

Significantly more root weight was recorded after 45 DAS compared to 75 DAS and 105 DAS the later two were not significant different. The root weight was in the order – 75 DAS < 105 DAS < 45 DAS.

D. Nematode population in 500 gm soil

Year 1995-96 (Table 15a) Graph-15

a.1 Effect of treatments :

The observations show that the nematode population in Neem (13.67) and linseed (14.17) was not significant to each other but less than soybean (16.00), mustard (18.00) and control (22.00) which were significantly different from each other.

Table 15 Management of *Pratylenchus thornei* on chickpea due to Oil cake: Nematode population in 500 gm soil.

Table No 15a 1995-96 Three replicates

OIL CAKE	45das	90 das	MEAN
NEEM	10.00	17.33	13.67
SOYABEAN	12.00	20.00	16.00
LINSEED	10.33	18.00	14.17
MUSTARD	13.67	22.33	18.00
CONTROL	17.67	26.33	22.00
DAS	12.73	20.80	

C.D. DAS at 5% 1.13

C.D. Treatment at 5% : 1.79

Table No 15b 1996-97 Four replicates

OIL CAKE	30 das	60das	90das	120das	MEAN
NEEM	16	12	12	71	27.56
SOYABEAN	17	15	19	50	22.88
LINSEED	20	16	13	61	27.25
MUSTARD	17	13	12	78	29.81
CONTROL	27	32	24	74	38.88
DAS	19.10	17.35	15.85	64.80	

C.D. DAS at 5% 7.2230

C.D. Treatment at 5% : 8.0756

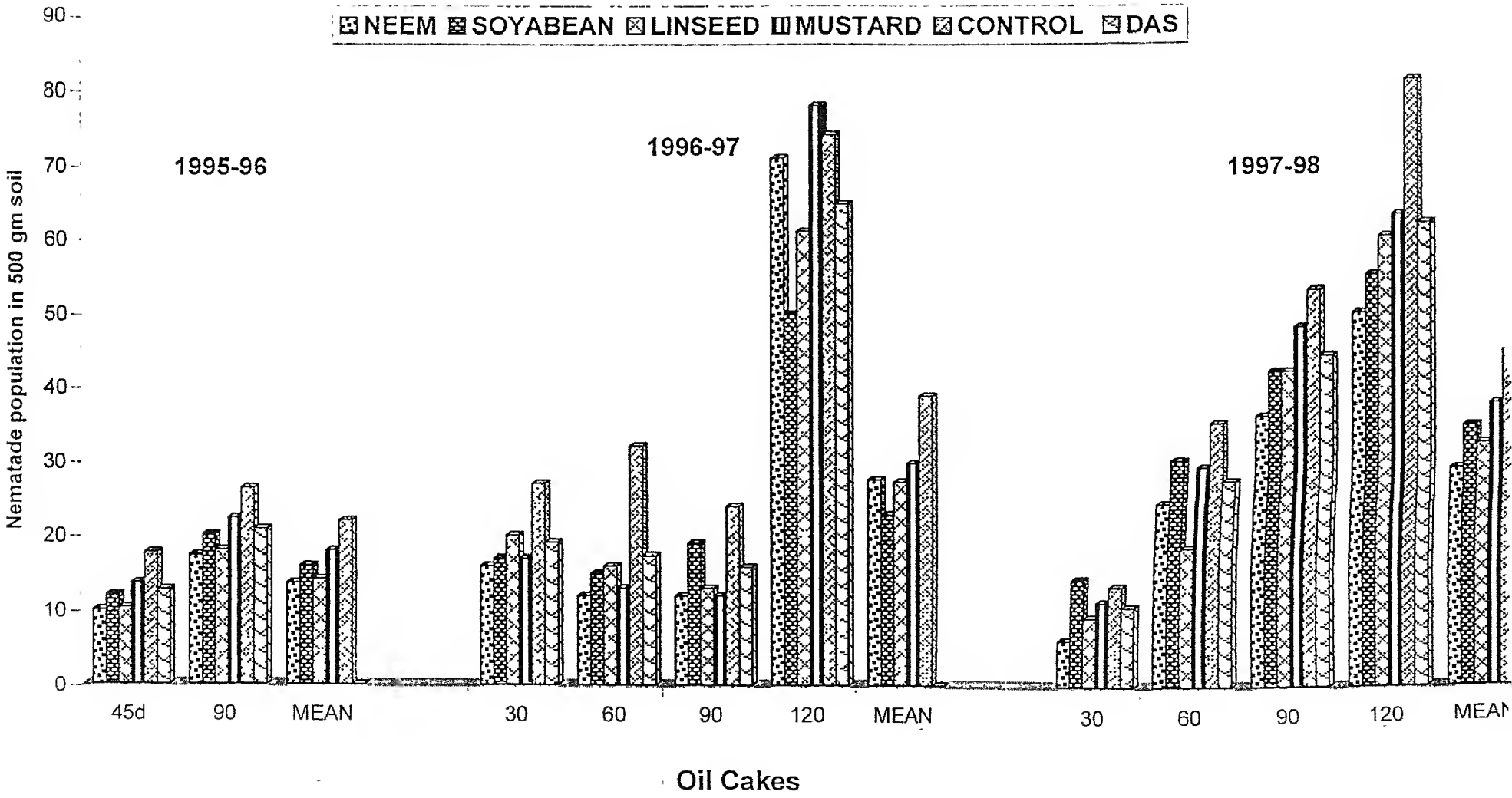
Table No 15c 1997-98 Four replicates

OIL CAKE	30 das	60das	90das	120das	MEAN
NEEM	6	24	36	50	29.06
SOYABEAN	14	30	42	55	34.88
LINSEED	9	18	42	60	32.38
MUSTARD	11	29	48	63	37.81
CONTROL	13	35	53	81	45.06
DAS	10.35	27.05	44.15	61.80	

C.D. DAS at 5% 7.2302

C.D. Treatment at 5% : 8.0836

Graph: 15. Management of *Pratylenchus thornei* on chickpea due to Oil cake. Nematode population in 500 gm soil.



a.2 Effect of DAS :

Significantly more nematode population was recorded after 90 DAS compared to 45 day after sowing. The nematode population being - 12.73 and 20.80, respectively.

Year 1996-97 (Table 15b) :

b.1 Effect of treatments :

The data shows that the nematode population in soybean (22.88), linseed (27.25), Neem (27.56), mustard (29.81) was not significantly different from each other but lesser as compared to control (38.88).

b.2 Effect of DAS :

Significantly more nematode population was recorded after 120 DAS compared to 90 DAS, 60 DAS and 30 days after sowing which were no significantly different from each other. The nematode population was recorded in the order - 90 DAS < 60 DAS < 30 DAS < 120 DAS.

Year 1997-98 (Table 15c) :

c.1 Effect of treatments :

The observations show that the nematode population was in the order – Neem (29.06) < linseed (32.30) < soybean (34.88) < mustard (37.81) < control (45.06); with out significant deference in each other.

c.2 Effect of DAS :

The nematode population was recorded in the order 30 DAS < 60 DAS < 90 DAS < 120 DAS of chickpea; with significant difference form each other in each day

E. **Nematode population per gm of root**

Year 1995-96 (Table 16a) Graph-16

a.1 **Effect of treatments :**

The data presents that the Neem, soybean, linseed and mustard cakes significantly reduced, the population of nematode as compared to control. The order of nematode population was Neem < soybean < linseed < mustard; cakes showing significantly difference from each other.

a.2 Effect of DAS :

Significantly more nematode population was recorded after 90 DAS compared 45 days after sowing, the nematode population being 7 and 5 respectively.

Year 1996-97 (Table 16b)

b.1 Effect of treatments :

The observations show that the nematode population per gm of root was in the order – Neem < Mahua < linseed < mustard < control; Neem was significantly less as compared to control; with Mahua, linseed and mustard not significantly different from each other.

b.2 Effect of DAS

Significantly more nematode population was recorded after 75 DAS and 105 DAS compared to 45 DAS. The nematode population was in the order 45 DAS < 75 DAS < 105 DAS.

Year 1997-98 (Table 16c)

c.1 **Effect of treatments :**

The observation show that the nematode population was in the order – Neem < mustard < linseed < Mahua < control; Neem, mustard, linseed were not

Table 16 Management of *Pratylenchus thornei* on chickpea due to Oil cake: Nematode population per gm of root system.

Table No 16a 1995-96 Three replicates

OIL CAKE	45das	90 das	MEAN
NEEM	2	4	3
SOYABEAN	4	7	5
LINSEED	5	8	6
MUSTARD	6	8	7
CONTROL	7	9	8
DAS	5	7	

C.D. DAS at 5% 0.5546

C.D. Treatment at 5% : 0.8770

Table No 16b 1996-97 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	03	03	04	03
MAHUA	05	07	06	06
LINSEED	03	11	06	07
MUSTARD	05	06	09	07
CONTROL	05	13	19	13
DAS	04	08	09	

C.D. DAS at 5% 2.1366

C.D. Treatment at 5% : 2.7583

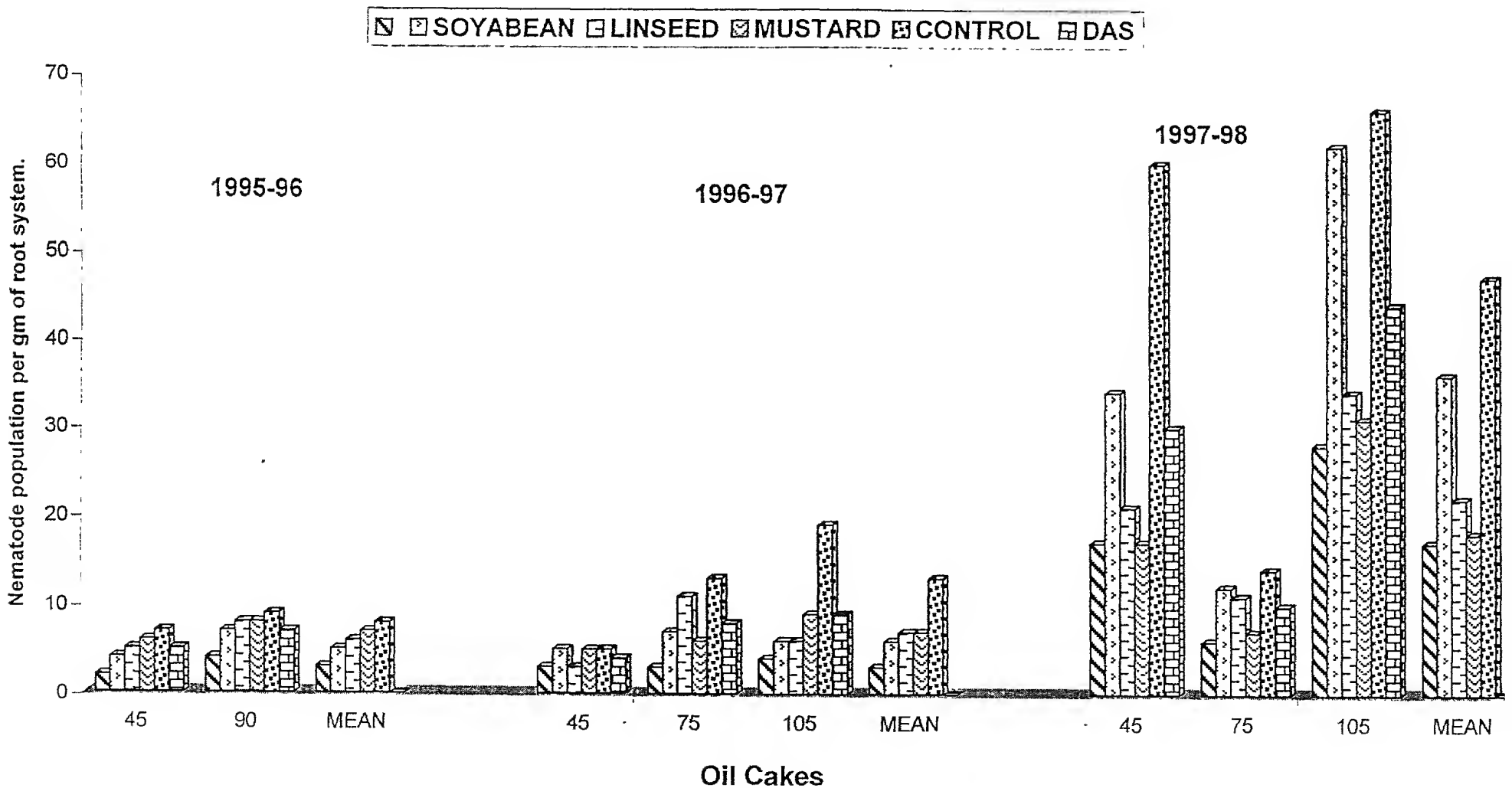
Table No 16c 1997-98 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	17	06	28	17
MAHUA	34	12	62	36
LINSEED	21	11	34	22
MUSTARD	17	07	31	18
CONTROL	60	14	66	47
DAS	30	10	44	

C.D. DAS at 5% 11.9636

C.D. Treatment at 5% : 15.4453

Graph: 16. Management of *Pratylenchus thornei* on chickpea due to Oil cake: Nematode population per gm of root system.



significantly deffer in each other but less to control; with Neem, mustard and linseed; linseed, Mahua; Mahua and control not significantly different from each other.

c.2 Effect of DAS :

The nematode population per gm of root was recorded in the order 75 DAS < 45 DAS < 105 days after sowing of chickpea; with significant difference from each other.

F. Number of nodules (two plants)

Year 1995-96 (Table 17a) Graph-17

a.1 Effect of treatments :

The data on number of nodules represents that there was no significant difference in number of nodules in linseed, soybean, Neem and mustard as also from control. The order was - linseed < soybean < Neem < mustard < control.

a.2 Effect of DAS :

Number of nodules was recorded in the order – 45 DAS < 90 days after sowing of chickpea; with significant difference from each other on each day.

Year 1996-97 (Table 17b)

b.1 Effect of treatments :

The data on number of nodules represents that there was no significant difference in number of nodules in linseed, mustard, Mahua and control as also from Neem. The order was linseed < mustard < Mahua < control < Neem.

b.2 Effect of DAS :

The number of nodules was in the order – 75 DAS < 105 DAS < 45 DAS with 75 DAS and 105 DAS, 105 DAS and 45 DAS not being significantly different from each other.

Year 1997-98 (Table 17c)

c.1 Effect of treatments :

The data on number of nodules represents that there was no significant difference in number of nodules in Neem, control, linseed and Mahua as also from mustard. The order was - Neem < control < linseed < Mahua < mustard.

c.2 Effect of DAS :

Significantly more number of nodules were recorded after 45 DAS compared to 105 DAS and 75 DAS after sowing with the latter two not significantly different from each other. The number of nodules was in the order – 105 DAS < 75 DAS < 45 DAS.

F. Weight of 10 nodules in mg

Year 1995-96 (Table 18a) Graph-18

a.1 Effect of treatments :

The observation show that the weight of 10 nodules in mg was in the order – linseed < soybean < mustard < control < Neem; with Neem & control; mustard & control; linseed & control not significantly different from each other.

Table 17 Management of *Pratylenchus thornei* on chickpea due to Oil cake: Number of nodules (Two plant).

Table No 17a 1995-96 Three replicates

OIL CAKE	45das	90 das	MEAN
NEEM	40.00	66.00	53.00
SOYABEAN	52.67	50.67	51.67
LINSEED	31.67	51.67	41.67
MUSTARD	50.00	56.67	53.17
CONTROL	54.33	53.00	53.67
DAS	45.33	55.33	
C.D. DAS at 5%	6.4189		

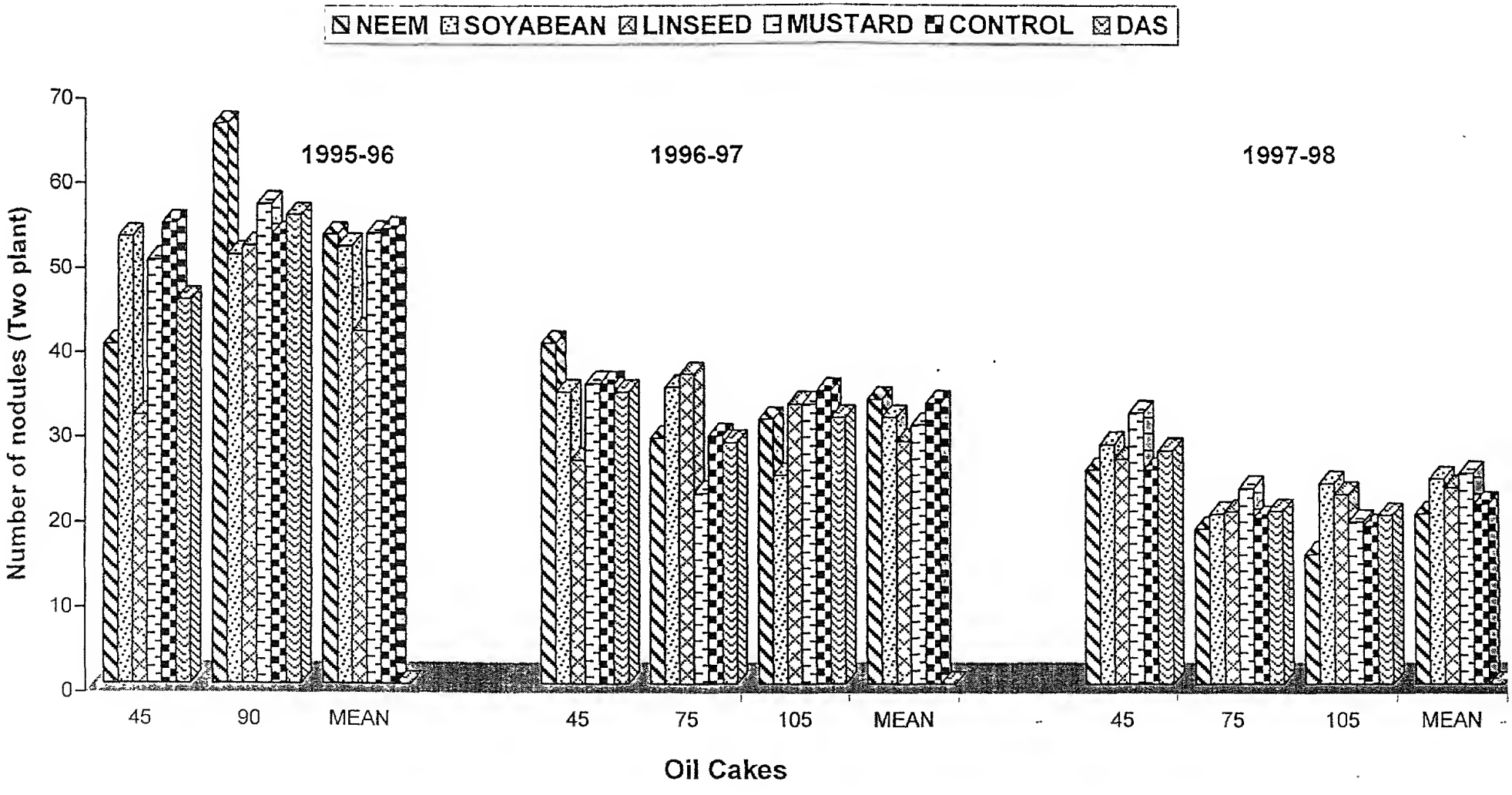
Table No 17b 1996-97 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	40.25	29.00	31.25	33.50
MAHUA	34.50	35.00	24.60	31.38
LINSEED	26.50	36.50	33.00	28.57
MUSTARD	35.50	22.50	33.00	30.50
CONTROL	35.50	29.25	34.50	33.08
DAS	34.45	28.45	31.35	
C.D. DAS at 5%	4.3799			

Table No 17c 1997-98 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	25.25	18.25	15.25	19.92
MAHUA	28.25	20.00	23.50	24.00
LINSEED	26.50	20.25	22.25	23.00
MUSTARD	32.00	23.00	19.00	24.67
CONTROL	25.25	19.50	18.50	21.08
DAS	27.50	20.30	19.80	
C.D. DAS at 5%	3.9183			

Graph: 17 Management of *Pratylenchus thornei* on chickpea due to Oil cake. Number of nodules (Two plant).



Year 1996-97 (Table 18b)

b.1 Effect of treatments :

The data on weight of 10 nodules in mg shows that there was no significant difference in weight of 10 nodules in Mahua, Neem, control and linseed as also from mustard.

b.2 Effect of DAS :

Significantly more weight of 10 nodules in mg was recorded after 75 DAS compared to 105 DAS and 45 DAS after sowing, the latter two showed significant difference from each other. The weight of 10 nodules in mg in the order – 105 DAS < 45 DAS < 75 DAS.

Year 1997-98 (Table 18 c)

c.1 Effect of treatments :

The observations show that the weight of 10 nodules in mg was in the order – control < linseed < Neem < Mahua < mustard; linseed, Neem, Mahua, mustard was significantly higher compared to control; with Mahua and mustard not significantly different from each other.

c.2 Effect of DAS :

The weight of 10 nodules in mg decreased significantly at 105 DAS, 75 DAS and 45 days after sowing on chickpea with significant difference on each day.

Table 18 Management of *Pratylenchus thornei* on chickpea due Oil cake: Weight per 10 nodules (in mg)

Table No 18a 1995-96 Three replicates

OIL CAKE	45das
NEEM	223.33
SOYABEAN	96.67
LINSEED	80.00
MUSTARD	170.00
CONTROL	210.00

C.D. DAS at 5% 49.3386

Table No 18b 1996-97 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	295.00	300.00	197.50	264.17
MAHUA	197.00	307.50	207.50	237.50
LINSEED	240.00	468.75	192.50	300.42
MUSTARD	267.50	380.00	287.50	311.67
CONTROL	341.25	292.50	243.75	292.50
DAS	268.25	347.75	225.75	

C.D. DAS at 5% 47.0724

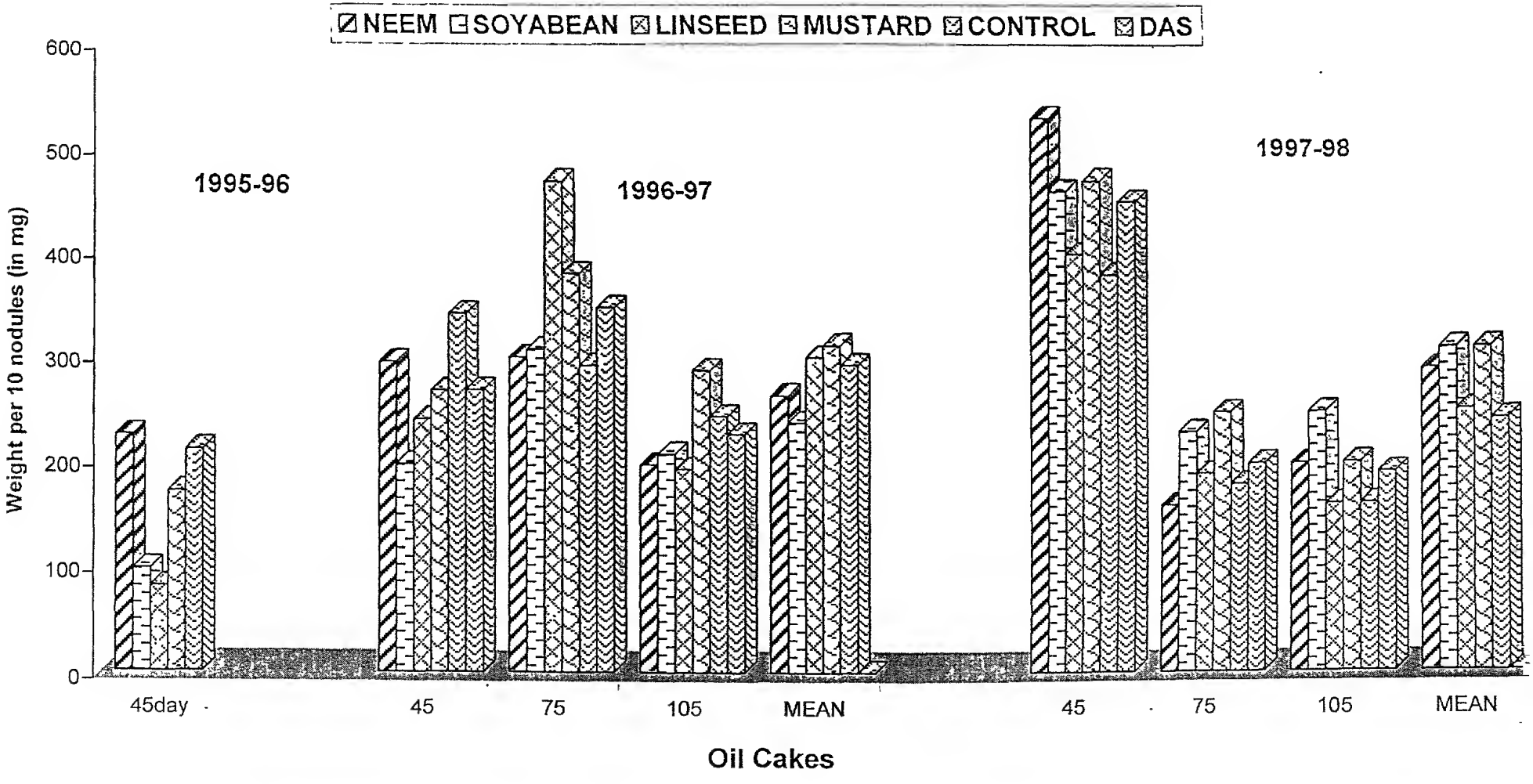
Table No 18c 1997-98 Four replicates

OIL CAKE	45das	75 das	105 das	MEAN
NEEM	530.00	160.00	200.00	290.00
MAHUA	460.00	230.00	250.00	310.00
LINSEED	400.00	190.00	160.00	250.00
MUSTARD	470.00	250.00	200.00	310.00
CONTROL	380.00	180.00	160.00	240.00
DAS	450.00	200.00	190.00	

C.D. DAS at 5% 5.6127

7.2460

Graph 18: Management of *Pratylenchus thornei* on chickpea due Oil cake: Weight per 10 nodules (in mg)



6. Management of *Pratylenchus thornei* on chickpea with cropping pattern

A. Shoot length in cm per plant

Year 1996-97 (Table 19a) Graph-19

a.1 Effect of Cropping Pattern-

The mixed cropping significantly increased shoot length per plant i.e. 39.90 cm in comparison to inter cropping 36.01cm.

a.2 Effect of treatment :

The treatment C+P , C+B, C+W and C+L were significantly superior in providing increased shoot length viz; 48.58, 39.16, 39.00 and 38.95 respectively in comparison to control 32.08cm.

a.3 Effect of DAS :

The 105 DAS, 75 DAS and 45 DAS were significant in each other, provided 53.22, 39.42 and 21.22 cm shoot length respectively.

Year 1997-98 (Table 19b)

b.1 Effect of Cropping Pattern-

The mixed cropping was significantly superior in reducing the shoot length 35.76 cm. in comparison to intercropping 40.65cm.

b.2 Effect of treatments :

All the treatments were showing no significant differences between them by providing 37.81, 37.83, 38.02, 38.14 and 39.25 cm soot length in C+P, C+W, C+B, C+L and control respectively.

b.3 Effect of DAS :

The effect of days after sowing was significant, having 23.61cm, 34.57cm and 56.45cm. Shoot length after 45/75 and 105 days of sowing.

B. Shoot weight in gm (two plants)

Year 1995-96 (Table 20a) Graph-20

a.1 Effect of treatments :

The observations showed that the shoot weight in gm in cp + wheat (4.70), cp + pea (4.70), cp + barley (6.78) and cp + linseed (7.40) was not significantly different from each other and was significantly less tham to control (18.22).

Table 19 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Shoot length per plant in cm

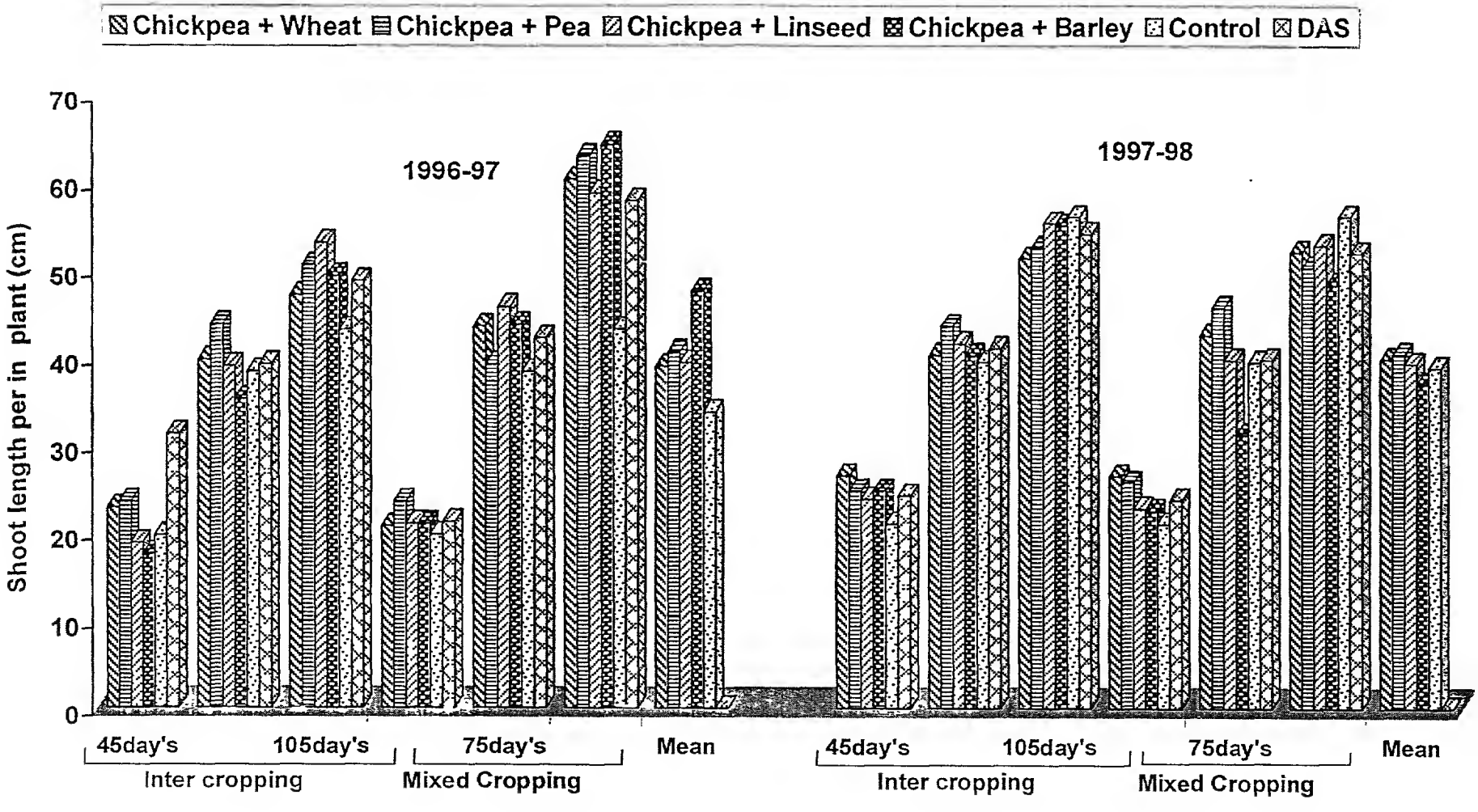
Table 19a 1996-97 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	22.75	39.75	47.00	20.75	43.50	60.25
Chickpea + Pea	23.50	43.75	50.50	23.50	39.25	63.00
Chickpea + Linseed	18.75	39.00	53.00	21.00	45.25	58.75
Chickpea + Barley	21.50	35.25	49.25	21.00	43.75	64.25
Control	19.75	33.37	43.12	19.75	33.37	43.12
Cropping pattern	C1	C2				C.D.
	36.01	39.90				2.03
Treatments	T5	T3	T1	T4	T2	C.D.
	32.08	38.95	39.00	39.16	40.58	2.49
DAS	D1	D2	D3			C.D.
	21.22	39.42	53.22			5.58

Table 19b 1997-98 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	25.0	42.5	56.25	23.8	24.8	54.8
Chickpea + Pea	24.5	40.25	59.0	23.8	25.4	54.6
Chickpea + Linseed	25.9	39.8	54.8	23.3	27.5	57.8
Chickpea + Barley	24.8	42.0	57.5	24.3	24.6	55.0
Control	20.5	39.50	57.8	20.5	39.5	57.8
Cropping pattern	C1	C2				C.D.
	40.65	35.76				1.29
Treatments	T2	T1	T4	T3	T5	C.D.
	37.81	37.83	38.02	38.14	39.25	1.59
DAS	D1	D2	D3			C.D.
	23.61	34.51	56.45			3.55

Graph: 19. Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern
Shoot length per plant in cm



a.2 Effect of DAS :

Significantly more shoot weight in gm was recorded after 90 DAS as compared to 45 DAS after sowing, being – 12.12 and 4.06 respectively.

Year 1996-97 (Table 20b)

b.1 Effect of Cropping Pattern-

The mixed cropping was significantly superior in shoot weight per two plant having 38.78gm in comparison to intercropping 34.02gm.

b.2 Effect of treatments :

The effect of treatment C+W and C+B were provided significantly higher shoot weight, 39.33 and 37.58 gm per two plant, while C+P and Control representing 36.25 and 35.38gm shoot weight. The C+L was provided least 33.23 gm shoot weight per two plant.

b.3 Effect of DAS :

After 105 DAS, 75 DAS and 45 DAS were provided significant shoot weight per two plant, being 66.81, 27.78 and 14.60 gm respectively.

Year 1997-98 (Table 20c)

c.1 Effect of Cropping Pattern-

The mixed cropping produced significantly higher shoot weight 31.46gm in comparison to intercropping 24.49gm.

c.2 Effect of treatments :

The treatment C+B, C+L, C+P and C+W were increased the shoot weight, i.e. 32.45/31.9, 31.42 and 27.97 gm, in comparison to control 24.05gm.

c.3 Effect of DAS

The effect of Days after sown was significant by increasing shoot weight, 15.96, 28.56 and 43.91 gm after 45, 75 and 105 days sown respectively.

C. Root weight in gm

Year 1995-96 (Table 21a) Graph-21

a.1 Effect of treatments :

The observations showed that the root weight in gm in cp + wheat (1.36), cp + barley (1.58), cp + pea (1.78) and cp + linseed (1.83gm) was not significantly different from each other but significantly less to control (2.98gm)

Table 20 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Shoot weight per two plant in gm

Table 20a 1995-96 Three replicates

Cropping pattern	Mixed Cropping		
	45 day	90 day	Mean
Chickpea + Wheat	3.73	5.67	4.70
Chickpea + Pea	3.43	5.97	4.70
Chickpea + Linseed	5.73	9.07	7.40
Chickpea + Barley	2.97	6.60	6.78
Control	7.13	29.30	18.22
DAS	4.60	12.12	-

CD DAS at 5% : 3.8089
CD Treat. at 5% : NS

Table 20b 1996-97 Four replicates

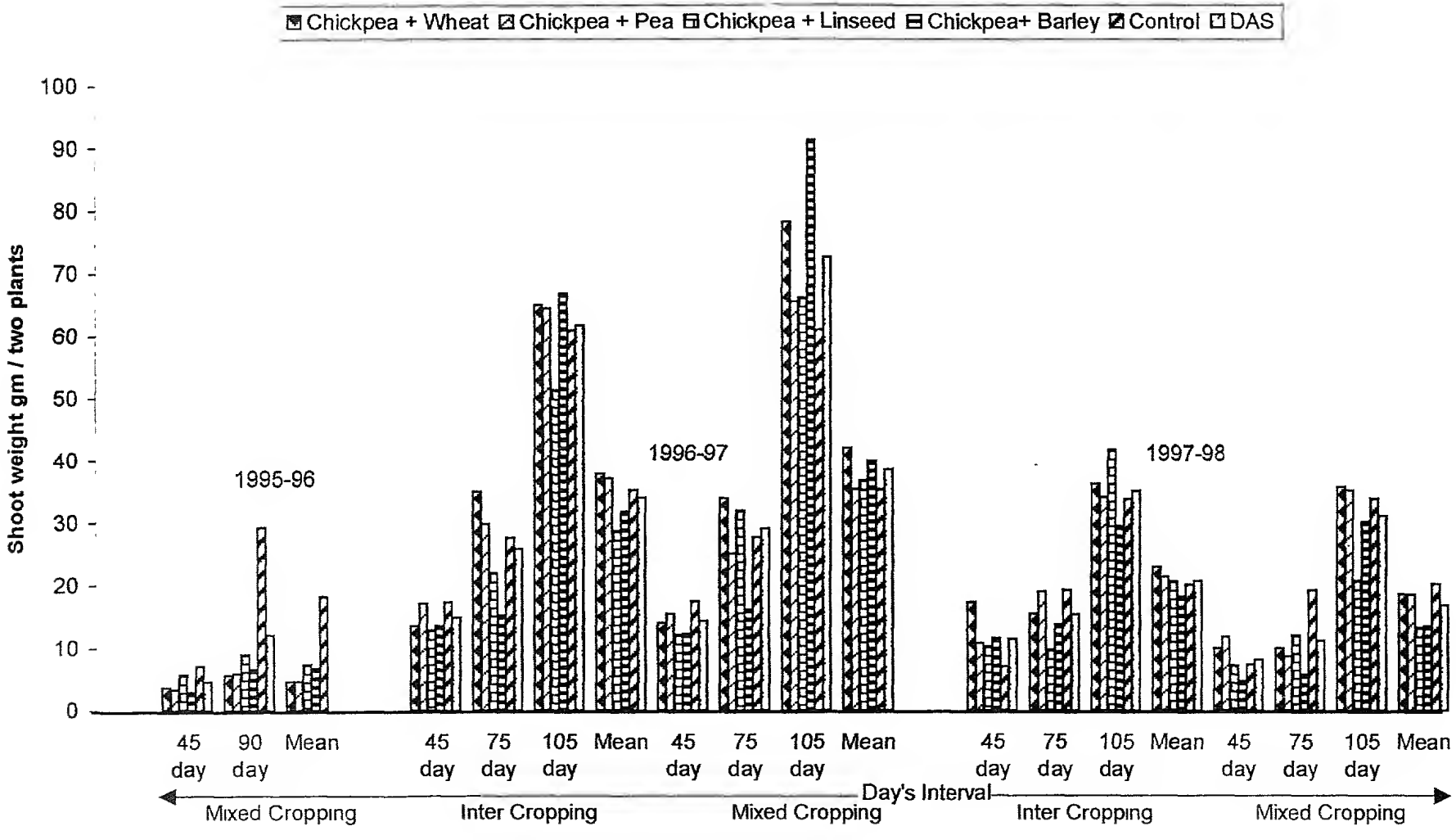
Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	13.52	35.12	64.42	13.95	34.06	78.25
Chickpea + Pea	17.22	29.80	64.30	15.55	25.15	65.50
Chickpea + Linseed	12.87	21.91	51.42	12.10	35.01	66.10
Chickpea + Barley	13.55	15.22	66.85	12.32	26.18	91.38
Control	17.48	27.70	60.96	17.42	27.70	60.97
Cropping pattern	C1	C2				C.D.
	34.02	38.78				2..39
Treatments	T3	T5	T2	T4	T1	C.D.
	33.23	35.38	36.25	37.58	39.55	2.93
DAS	D1	D2	D3			C.D.
	14.60	27.78	66.81			6.56

Table 20c 1997-98 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	16.3	37.3	35.3	14.4	19.6	45.1
Chickpea + Pea	16.5	35.8	50.8	18.7	18.8	48.1
Chickpea + Linseed	21.5	37.3	42.9	16.8	23.6	48.1
Chickpea + Barley	16.5	41.9	48.1	14.6	16.6	55.8
Control	12.3	27.4	32.5	12.3	27.4	32.5

Cropping pattern	C1	C2				C.D.
	24.49	31.46				4.02
Treatments	T5	T1	T2	T3	T4	C.D.
	24.05	27.97	31.42	31.69	32.25	4.93
DAS	D1	D2	D3			C.D.
	15.96	28.56	43.91			11.02

Graph : 20. Management of *Pratylenchus thornei* on chickpea dur to cropping Pattern: Shoot weight in gm (Two Plant)



a.2 Effect of DAS :

Significantly more root weight in gm was recorded after 90 DAS compared to 45 DAS after sowing, isbeing 1.52 and 2.29gm respectively.

Year 1996-97 (Table 21b)

b.1 Effect of Cropping Pattern-

The mixed cropping significantly superior in providing more root weight (3.52gm) per two plant in comparison to intercropping 3.23g.

b.2 Effect of treatments :

The effect of treatment C+W was significantly superior to all other treatment, having 4.00 gm higher root weight. The treatment C+P, C+B and C+L provided 3.43, 3.21, and 3.17gm root weight in comparison control (3.07gm).

b.3 Effect of DAS :

The effect of days of sowing showed that 105 DAS having significant maximum root weight (4.85gm) per two plant, while 75 DAS and 45 DAS supplied 2.76 and 2.52 gm root weight.

Year 1997-98 (Table 21c)

c.1 Effect of Cropping Pattern-

The cropping pattern indicate that, there is no significant difference in mixed cropping (3.23) and intercropping (3.27) gm root weight per two plant.

c.2 Effect of treatments :

All the treatment C+P, C+L, C+B and C+W were providing (3.69), (3.61), (3.41) and (3.16) gm root weight per two plant as compared to control (2.38gm).

c.3 Effect of DAS

The 75 DAS and 45 DAS were not different to each other provided (3.74) and (3.70) gm root weight per two plant, while 105 DAS gave (2.31gm) root weight.

D. Nematode population of 500 gm soil

Year 1995-96 (Table 22a) Graph-22

a.1 Effect of treatments :

The observations show that the nematode population of 500 gm soil was in the order – cp + wheat < cp + linseed < cp + barley < cp + pea < control; but they not different to each other.

Table 21 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Root weight in gm (two plant)

Table 21a 1995-96 Three replicates

Cropping pattern	Mixed Cropping		
	45 day	90 day	Mean
Chickpea + Wheat	1.23	1.47	1.35
Chickpea + Pea	1.60	1.97	1.78
Chickpea + Linseed	1.17	2.50	1.83
Chickpea + Barley	1.10	2.07	1.58
Control	2.50	3.47	2.98
DAS	1.52	2.29	

CD DAS at 5% : 0.4016

CD Treat. at 5% : 0.6350

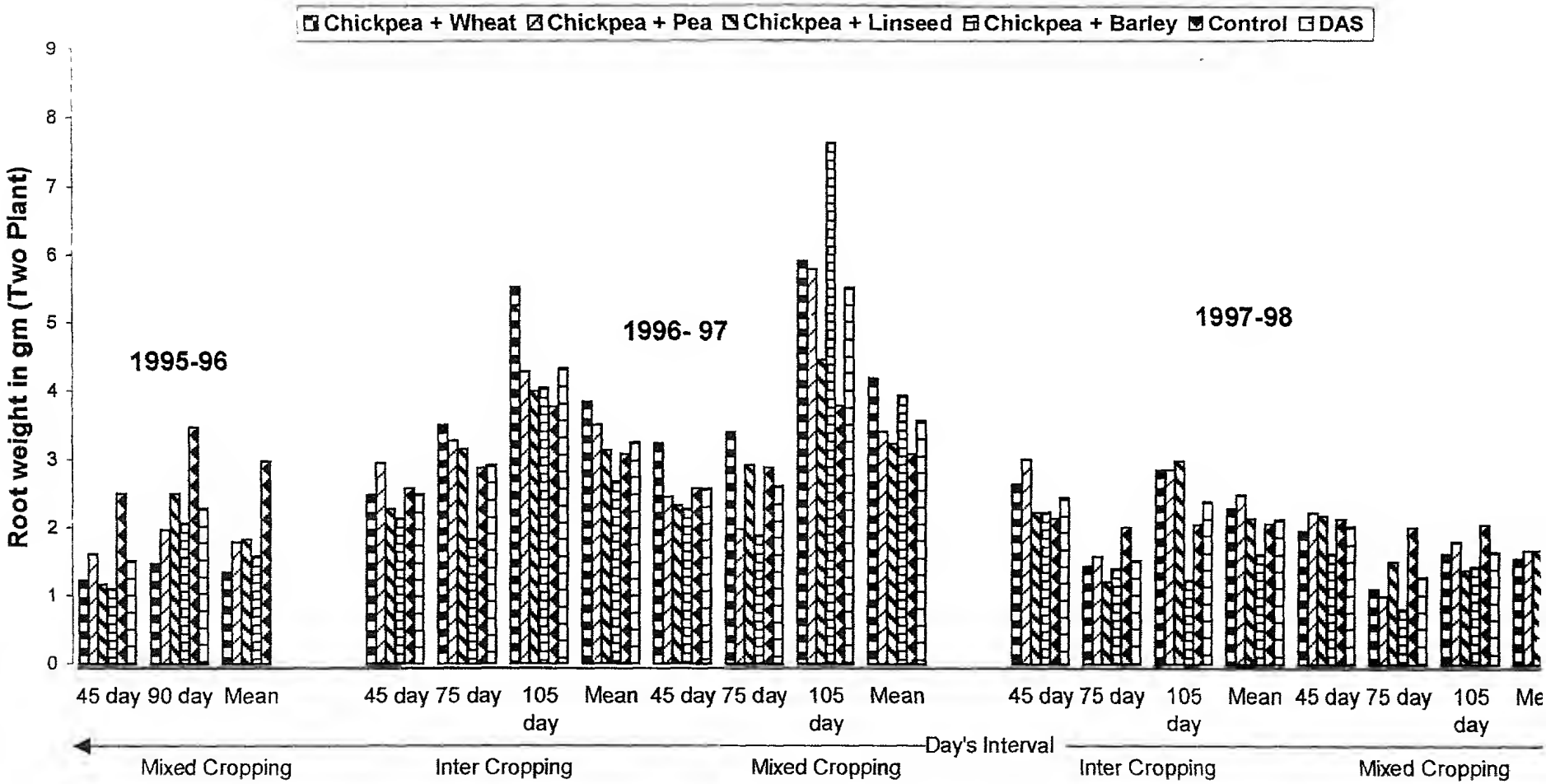
Table 21b 1996-97 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	2.48	3.50	5.52	3.22	3.40	5.90
Chickpea + Pea	2.95	3.27	4.17	2.45	1.97	5.77
Chickpea + Linseed	2.27	3.12	4.00	2.32	2.90	4.45
Chickpea + Barley	2.15	1.82	4.05	2.27	1.87	7.12
Control	2.57	2.87	3.77	2.57	2.87	3.77
Cropping pattern	C1	C2				C.D.
	3.23	3.52				0.173
Treatments	T5	T3	T4	T2	T1	C.D.
	3.07	3.17	3.21	3.43	4.00	0.212
DAS	D1	D2	D3			C.D.
	2.52	2.76	4.85			0.474

Table 21c 1997-98 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	3.10	3.45	1.95	3.78	4.20	2.50
Chickpea + Pea	4.23	3.85	2.83	4.23	4.10	2.75
Chickpea + Linseed	4.45	4.60	2.90	3.73	4.68	1.93
Chickpea + Barley	3.68	4.30	2.58	3.98	3.25	2.73
Control	2.85	2.50	1.80	2.85	2.50	1.80
Cropping pattern	C1	C2				C.D.
	3.27	3.23				0.355
Treatments	T5	T1	T4	T3	T2	C.D.
	2.38	3.16	3.41	3.61	3.69	0.434
DAS	D1	D2	D3			C.D.
	3.70	3.74	2.31			0.972

Graph 21: Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Root weight in gm (two plant)



a.2 Effect of DAS :

Significantly more nematode population was recorded after 90 DAS compared to 45 DAS after sowing, the nematode population being 245 and 145, respectively.

Year 1996-97 (Table 22b)

b.1 Effect of Cropping Pattern-

The intercropping provided significant reduced population (272.31) as compared to mixed cropping (314.81) nematodes.

b.2 Effect of treatments :

The treatment C+L, and C+B were significant to all other treatment by providing least 232.06 and 252.81 nematode population per 500gm of soil. The C+P and C+W were also showed less no. of population 291.25 and 293.12 respectively in comparison to control (391.56) nematodes.

b.3 Effect of DAS :

The effect of DAS after sowing showed 186.00, 192.50 and 214.00 after 90, 60 and 30 DAS respectively while 120 DAS showed 581.75 nematode per 500 gm soil.

Year 1997-98 (Table 22c)

c.1 Effect of Cropping Pattern-

The mixed cropping and intercropping showed no significant effect between them by providing 64.1 and 65.21 reduced nematode population per 500 gm Soil.

c.2 Effect of treatments :

The treatment C+L and C+P were significantly reduced the nematode population 56.81 and 57.56 in comparison to C+W (61.21), C+B (62.03) and Control 87.18 per 500 gm of Soil.

Table 22 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Nematode population 500 gm soil

Table 22a 1995-96 Three replicates

Cropping pattern	Mixed Cropping		
	45 day	90 day	Mean
Chickpea + Wheat	147	243	195
Chickpea + Pea	147	270	209
Chickpea + Linseed	137	260	199
Chickpea + Barley	140	245	199
Control	177	265	221
DAS	145	245	

CD DAS at 5% : 14.766
CD Treat. at 5% : 23.351

Table 22b 1996-97 Four replicates.

Cropping pattern	Inter cropping				Mixed cropping			
	30 day	60 day	90 day	120 day	30 day	60 day	90 day	120 day
Chickpea + Wheat	195.0	145.0	167.5	677.5	195.0	197.5	247.5	520.0
Chickpea + Pea	155.0	132.5	145.0	512.5	197.0	280.0	165.0	742.5
Chickpea + Linseed	170.0	55.0	80.0	382.5	247.5	145.0	245.0	587.5
Chickpea + Barley	247.5	202.5	170.0	442.5	170.0	130.0	155.0	505.0
Control	281.3	318.8	242.0	723.8	281.3	318.8	242.5	723.8

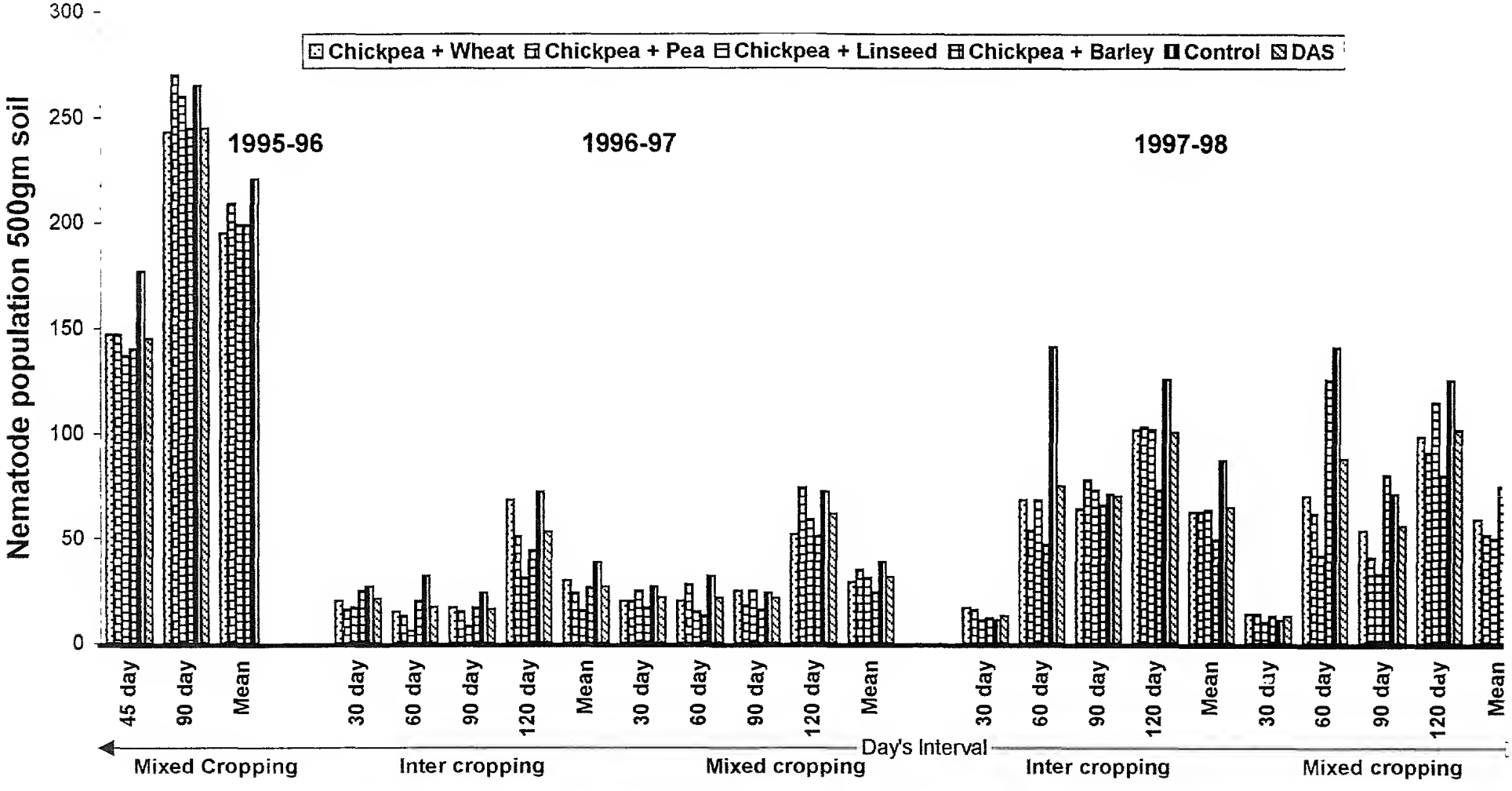
Cropping pattern	C1	C2				C.D.
	272.31	314.81				33.74
Treatments	T5	T1	T4	T3	T2	C.D.
	239.06	252.81	291.25	293.12	391.56	47.12
DAS	D1	D2	D3			C.D.
	186.0	192.50	214.0	581.75		106.69

Table 22c 1997-98 Four replicates

Cropping pattern	Inter cropping				Mixed cropping			
	30 day	60 day	90 day	120 day	30 day	60 day	90 day	120 day
Chickpea + Wheat	17.5	68.5	64.3	102.0	14.3	70.0	54.0	99.3
Chickpea + Pea	16.0	54.8	77.8	103.0	14.3	62.5	41.5	90.8
Chickpea + Linseed	11.5	68.0	72.8	102.0	10.0	42.0	33.3	115.0
Chickpea + Barley	12.0	47.0	65.8	72.0	13.0	126.0	79.3	80.3
Control	11.0	141.3	71.0	125.0	11.0	145.0	71.0	125.5

Cropping pattern	C1	C2						C.D.
	65.21	64.71						2.80
Treatments	T3	T2	T1	T4	T5			C.D.
	56.81	57.56	691.21	62.03	87.18			3.97
DAS	D1	D3	D2	D4				C.D.
	13.05	63.05	82.15	101.60				8.88

Graph 22: Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Nematode population 500 gm soil



c.3 Effect of DAS

The effect of all the days after sowing was significant between them by providing 30 DAS (13.05), 90 DAS (63.05), 60 DAS (82.15) and 120 DAS (101.60) nematode per 500 gm of Soil.

Nematode population per gm of root System

Year 1995-96 (Table 23a) Graph-23

a.1 Effect of treatments :

The data on nematode population per gm of root was in the order cp + wheat < cp + linseed < cp + pea < cp + barley < control. The nematode population was significantly less than control.

a.2 Effect of DAS :

Significantly more nematode population was recorded 90 DAS as compared to 45 days after sowing, the nematode population per gm of root being 74 and 53 respectively.

Year 1996-97 (Table 23b)

b.1 Effect of Cropping Pattern-

The mixed cropping was significantly reduced Nematode population (7.66) in comparison to intercropping (9.25) nematode per gm of root system.

b.2 Effect of treatments :

The effect of treatment C+B, C+L, and C+P were reduced the nematode population 6.12, 6.41 and 6.87, respectively while C+W and control providing 10.62 and 12.25 nematode per gm root system

b.3 Effect of DAS :

The effect of days after sowing showed that 45 DAS and 75 DAS were not differ in each other, having 4.05 and 7.05 nematode per gm of root system, while 105 DAS showed 14.27 nematode per gm of root system.

Table 23 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Nematode population per gm of root system

Table23a 1995-96 Three replicates

Cropping pattern	Mixed Cropping		
	45 day	90 day	Mean
Chickpea + Wheat	40	41	41
Chickpea + Pea	43	80	62
Chickpea + Linseed	38	70	54
Chickpea + Barley	70	88	79
Control	75	90	83
DAS	53	74	

CD DAS at 5% : 5.8365
CD Treat. at 5% : 9.282

Table 23b 1996-97 Four replicates

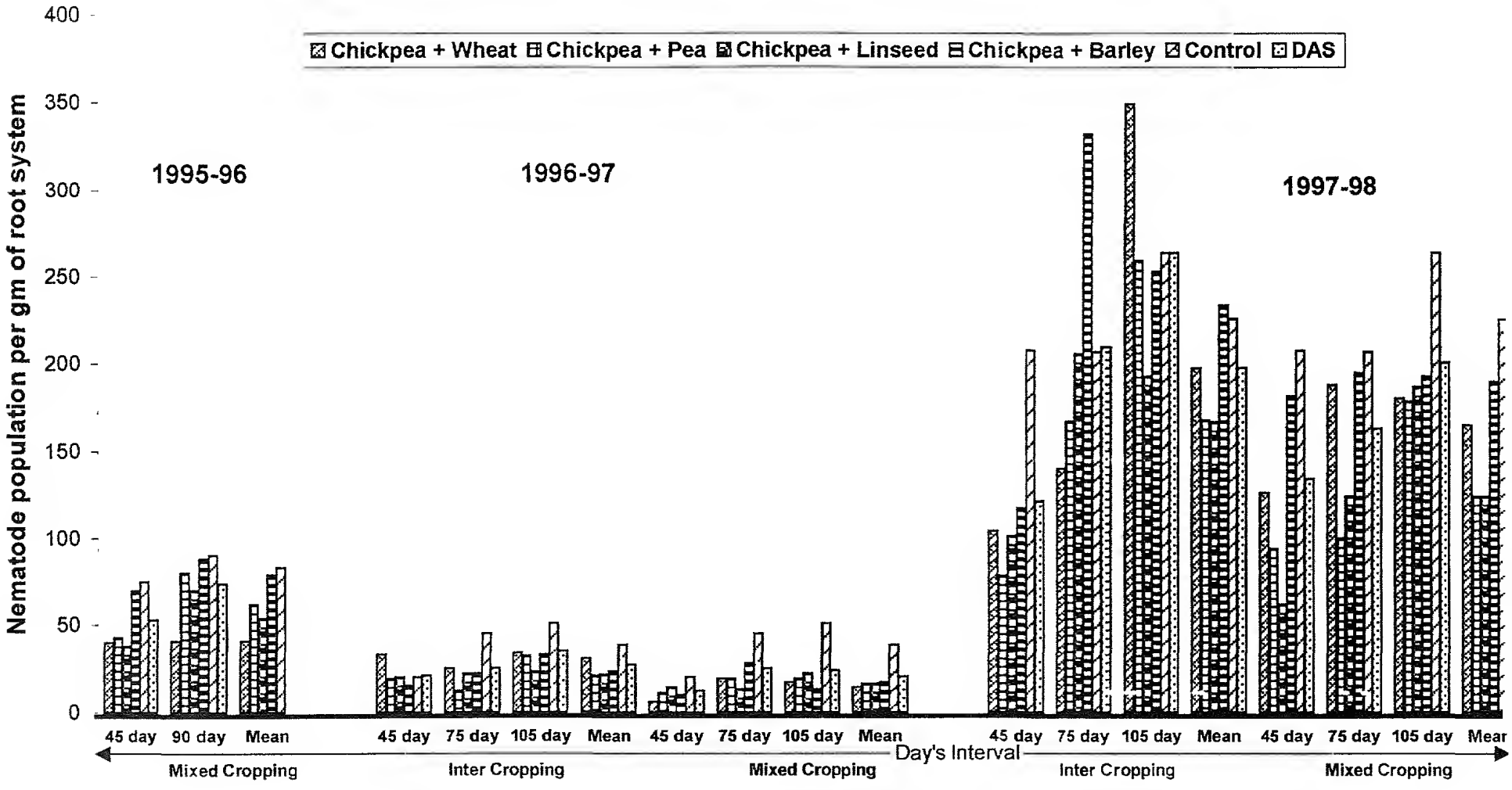
Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	8.25	10.75	18.25	2.00	5.50	19.00
Chickpea + Pea	5.75	4.00	14.5	2.75	3.75	10.50
Chickpea + Linseed	3.50	7.00	10.50	4.25	3.75	9.50
Chickpea + Barley	2.75	4.25	12.50	2.25	5.50	9.50
Control	4.50	13.00	19.25	4.50	13.00	19.50

Cropping pattern	C1	C2				C.D.
	9.25	7.66				1.49
Treatments	T4	T3	T2	T1	T5	C.D.
	6.12	6.41	6.87	10.62	12.25	1.83
DAS	D1	D2	D3			C.D.
	4.05	7.05	14.27			4.09

Table23c 1997-98 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	102.5	140.0	349.5	125.5	188.75	181.0
Chickpea + Pea	77.75	166.0	259.0	97.0	100.0	179.0
Chickpea + Linseed	102.5	207.0	173.0	63.0	124.5	186.0
Chickpea + Barley	116.0	338.5	253.25	183.0	195.25	193.0
Control	207.25	207.0	264.0	207.0	207.0	264.0
Cropping pattern	C1	C2				C.D.
	196.88	166.33				6.65
Treatments	T3	T2	T1	T4	T5	C.D.
	142.79	146.45	181.20	211.50	226.08	8.14
DAS	D1	D3	D2			C.D.
	54.67	56.54	61.52			18.21

Graph 23: Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Nematode population per gm of root system



Year 1997-98 (Table 23c)

c.1 Effect of Cropping Pattern-

It is evident from the data that mixed cropping was significantly superior in reducing the nematode population 166.37 per gm of root system in comparison to intercropping (196.8) nematodes.

c.2 Effect of treatments :

The effect of treatment showed that the chickpea _ Linseed and Chickpea + Pea were significantly superior from all the treatment and control by providing reduced 142.79 and 146.45 nematodes per gm of root system but they did not differ in each other. The treatments C+W and C+B were significant in each other by providing 181.20 and 211.50 reduced nematode population as compared to control 226.08.

c.3 Effect of DAS

The population of nematode per gm of root system was 54.67, (45 Days), 56.54 (105 days) and 61.52 (75 days), but they did not differ to each other.

F. Number of nodules per two plant

Year 1995-96 (Table 24a) Graph-24

a.1 Effect of treatments :

The data on number of nodules represents that there was no significant difference in number of nodules in cp + linseed, cp +barley, control and cp + pea & cp + wheat. The order was – cp + linseed < cp + barley < control < cp + pea < cp + wheat in number of nodules two plant.

a.2 Effect of DAS :

Number of nodules was recorded in the order – 45 DAS < 90 DAS ; with significant difference from each other.

Year 1996-97 (Table 24b)

b.1 Effect of Cropping Pattern-

The mixed cropping having significant higher number of modules (41.06) in comparison to intercropping (33.36) nodules per two plant.

Table 24 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Number of nodules per two plant

Table 24a 1995-96 Three replicates

Cropping pattern	Mixed Cropping		
	45 day	90 day	Mean
Chickpea + Wheat	55.33	64.00	59.67
Chickpea + Pea	55.00	60.67	57.83
Chickpea + Linseed	38.67	62.00	50.33
Chickpea + Barley	48.00	64.67	56.33
Control	56.00	56.67	57.83
DAS	50.60	62.20	

CD DAS at 5% : 6.4880
CD Treat. at 5% : NS

Table 24b 1996-97 Four replicates

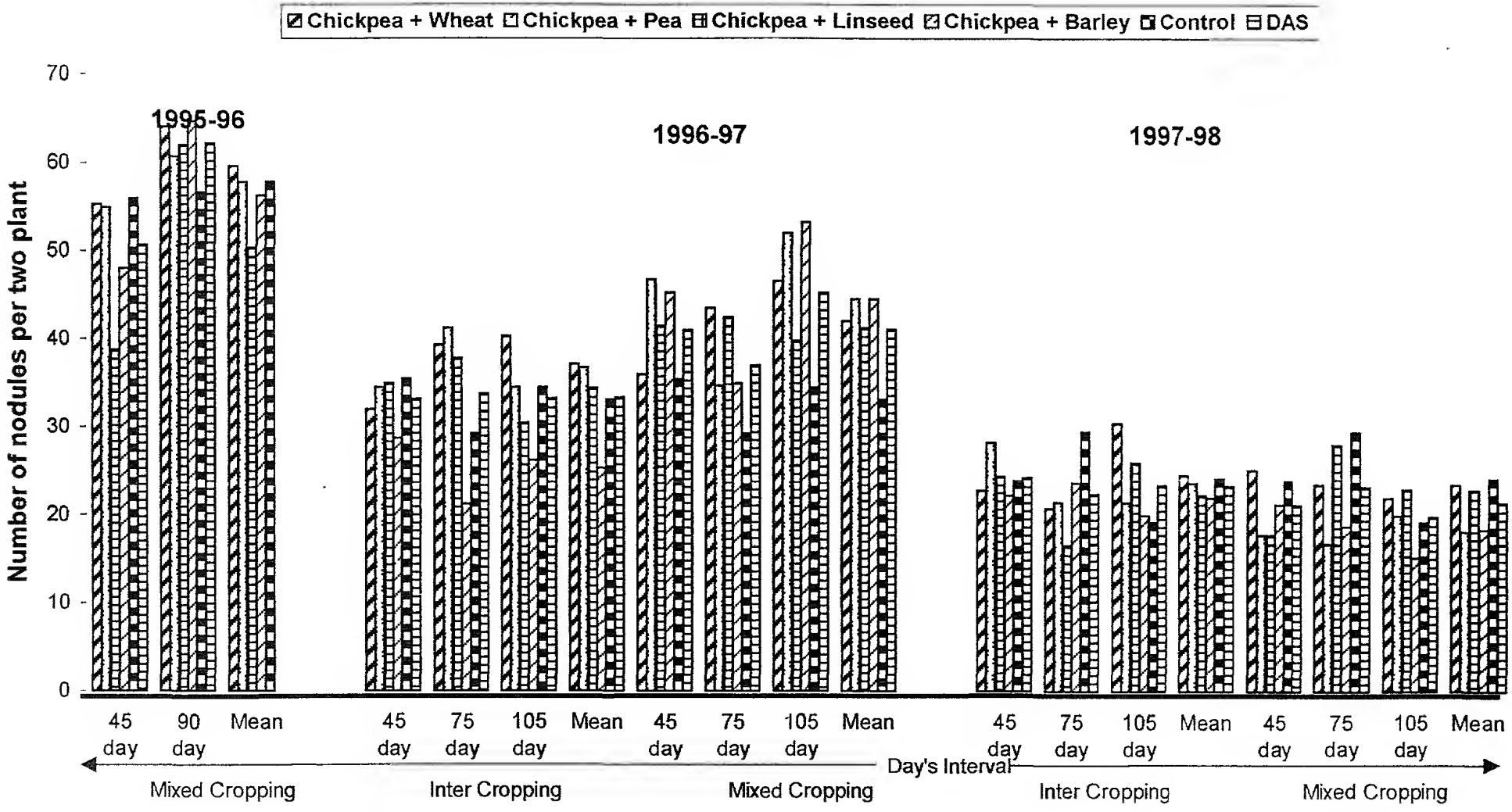
Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	32.00	39.25	40.25	36.00	43.50	46.50
Chickpea + Pea	34.50	41.25	34.50	46.75	34.75	52.00
Chickpea + Linseed	35.00	37.75	30.50	41.50	42.50	39.75
Chickpea + Barley	28.75	21.25	26.25	42.25	35.00	53.25
Control	35.50	29.25	34.50	35.50	29.25	34.50
Cropping pattern	C1	C2				C.D.
	33.36	41.06				2.30
Treatments	T5	T4	T3	T1	T2	C.D.
	33.08	34.95	37.83	39.58	40.62	2.82
DAS	D1	D2	D3			C.D.
	37.07	35.37	39.20			6.32

Table 24c 1997-98 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	18.3	25.0	20.8	25.5	24.5	25.3
Chickpea + Pea	30.5	26.8	18.0	23.8	28.0	19.8
Chickpea + Linseed	28.8	35.8	27.0	25.5	25.3	18.3
Chickpea + Barley	22.3	30.0	23.5	29.5	25.0	23.3
Control	20.3	21.8	20.0	20.3	21.8	20.0

Cropping pattern	C1	C2				C.D.
	241.58	23.70				3.14
Treatments	T5	T1	T2	T4	T3	C.D.
	20.66	23.2	24.45	25.62	26.75	3.85
DAS	D1	D2	D3			C.D.
	24.47	26.37	21.57			8.61

Graph 24: Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Number of nodules per two plant



b.2 Effect of treatments :

The treatment C+P, C+W and C+L were provided 40.62, 39.58 and 37.83 number of nodules per two plant but they did not differ in each other. The C+B and Control were not significant between them by making 34.95 and 34.08 nodules per two plant.

b.3 Effect of DAS :

The effect of day after sowing showed that 105 DAS, 45 DAS and 75 DAS were provided 39.20, 37.07 and 35.37 number of nodules per two plant but they did not differ to each other.

Year 1997-98 (Table 24c)

c.1 Effect of Cropping Pattern-

The effect of mixed cropping and intercropping was not significant between them by forming (23.70) and (24.58) nodules per two plant respectively.

c.2 Effect of treatments :

The treatment C+L and C+B were not differ to each other in formation of maximum no. of nodules per two plant i.e. (26.75) and (25.62) respectively. The C+P and C+W were also farming higher (24.45) and (23.20) nodules as comparison to control (20.66).

c.3 Effect of DAS

The effect of days after sowing was not significant between 75 DAS (26.37), 45 DAS (24.47) and 105 DAS (21.57) nodules formation per two plant.

G. Weight per 10 nodules in mg

Year 1995-96 (Table 25a) Graph-25

a.1 Effect of treatments :

The observations showed that the weight per 10 nodules in mg was not significantly different in cp + linseed, cp + wheat control and cp + pea as also from cp + barley. The order cp + linseed < cp + wheat < control < cp + pea < cp + barley in weight per 1- nodules.

a.2 Effect of DAS :

The mean weight per 10 nodules at 45 DAS was recorded as 206.66 mg.

Year 1996-97 (Table 25b)

b.1 Effect of Cropping Pattern-

The effect of mixed cropping was significantly highest (334.50) mg in comparison to inter cropping (248.50) mg weight per 10 nodules.

b.2 Effect of treatments :

The effect of treatment C+P and C+W were not differ to each other in weight per 10 nodules i.e. 320.83 and 312.08 mg respectively The control, C+L and C+B were not significant in each other by providing 288.33, 275.00 and 261.25 mg weight per 10 nodules respectively.

b.3 Effect of DAS :

The 45 DAS , 105 DAS and 75 DAS were provided weight of 10 nodules per two plants in descending order i.e. 320.75, 280.25 and 273.50 mg respectively.

Year 1997-98 (Table 25c)

c.1 Effect of Cropping Pattern-

There is no significant difference in mixed cropping and intercropping, representing 270.50 and 302.50 mg. Weight of 10 nodules.

c.2 Effect of treatments :

The treatment C+W , C+P, C+L and C+B were not significant to each other, but provided higher 10 nodules weight i.e 305.41m 301.25, 288.74 and 280.41 mg respectively in comparison to control (274.16mg).

c.3 Effect of DAS

The highest weight of 10 nodules was found 75 DAS (391.25) followed by 45 DAS (308.00) while 105 DAS represent (170.75 mg).

Table 25 Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Weight per 10 nodules in mg

Table 25a 1995-96 Three replicates

Cropping pattern	Mixed Cropping
	45 day
Chickpea + Wheat	196.67
Chickpea + Pea	216.67
Chickpea + Linseed	190.00
Chickpea + Barley	220.00
Control	210.00

CD DAS at 5% : NS
CD Treat. at 5% : 49.2787

Table 25b 1996-97 Four replicates

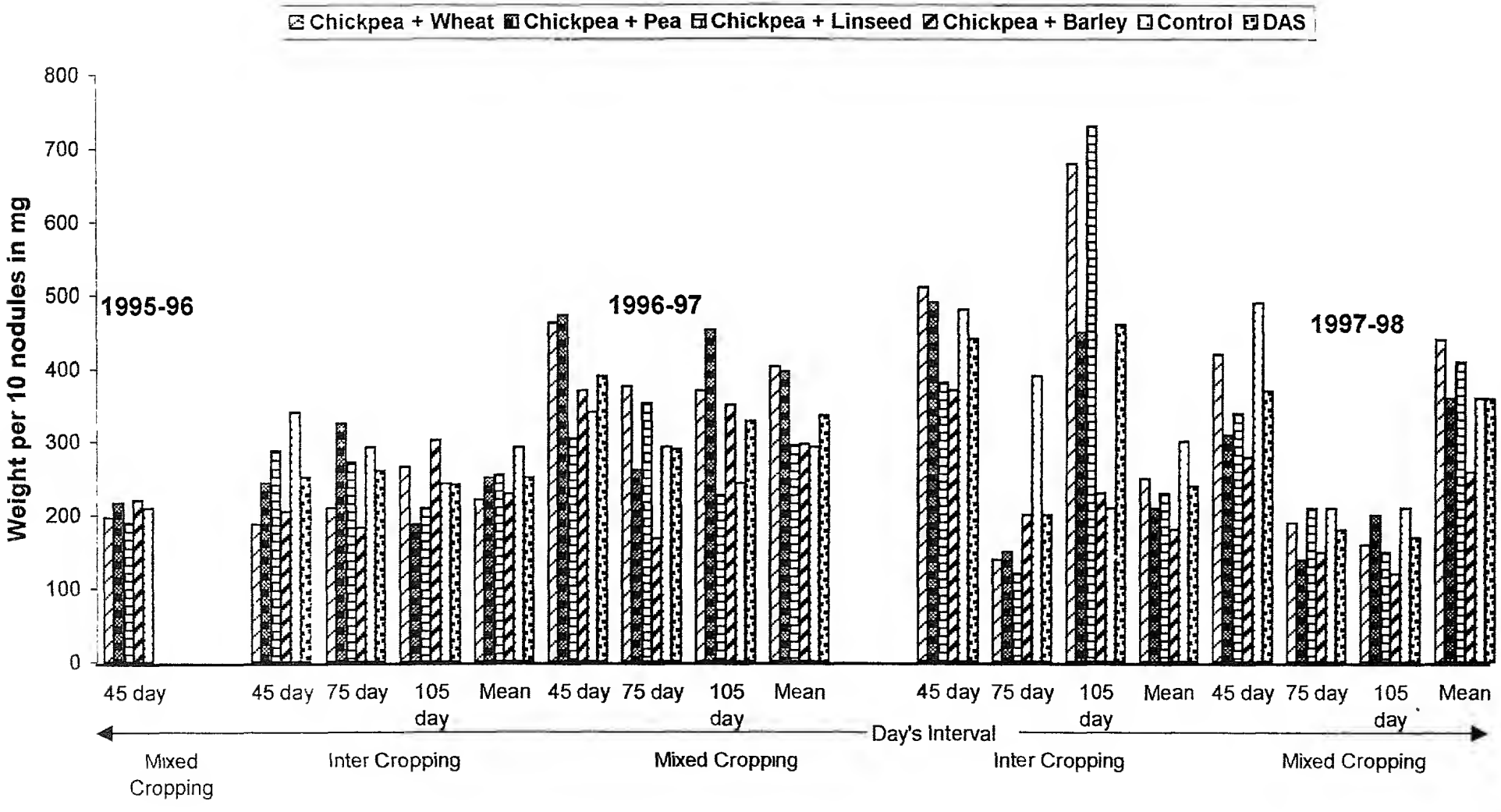
	Inter Cropping			Mixed Cropping		
Cropping pattern	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	187.50	210.00	267.50	462.50	375.00	370.00
Chickpea + Pea	245.00	325.50	160.00	472.50	262.50	452.50
Chickpea + Linseed	287.50	272.50	210.00	305.00	347.50	227.50
Chickpea + Barley	205.00	182.50	302.50	360.00	167.00	350.00
Control	341.30	292.50	231.30	341.00	292.00	231.30
Cropping pattern	C1	C2				C.D.
	248.50	334.50				24.52
Treatments	T4	T3	T5	T1	T2	C.D.
	261.25	275.00	288.33	312.08	320.83	30.03
DAS	D1	D2	D3			C.D.
	320.75	273.50	280.25			67.16

Table25c 1997-98 Four replicates

Cropping pattern	Inter Cropping			Mixed Cropping		
	45 day	75 day	105 day	45 day	75 day	105 day
Chickpea + Wheat	357.5	475.0	167.5	235.0	335.0	262.5
Chickpea + Pea	430.0	485.0	145.0	257.5	315.0	175.0
Chickpea + Linseed	237.5	477.5	200.0	245.0	397.0	175.0
Chickpea + Barley	237.5	325.0	177.5	390.0	427.5	125.0
Control	345.0	337.5	140.0	345.0	337.5	140.0

Cropping pattern	C1	C2				C.D.
	302.50	277.50				43.55
Treatments	T5	T4	T3	T2	T1	C.D.
	274.16	280.41	288.75	301.25	305.41	53.34
DAS	D1	D2	D3			C.D.
	308.0	391.25	170.75			119.28

Graph 25: Management of *Pratylenchus thornei* on chickpea due to Cropping Pattern: Weight per 10 nodules in mg



7. **Screening of chickpea varieties against *Pratylenchus thornei* (farmer field experiment)**

Nematode population per gram of root : (Table 26)

Highly Resistant (HR) 89 Number of nematode per gram of root was in the following – BG 267 AVT 1K, BG 362 AVT 1 BS, BG 390 AVT 1B, BG 391 AVT 2B-5, BG 1027 AVT,K, BG 1033 AVT,CS, BG1035 AVT,LS, BG256 AVT,VS, BG1039 AVT2 HFT, BG1043 AVT 1D, BG 1044 AVT1BS, BG 1045 AVT1BS, BG1047 AVT1 LS, BS 1051 AVT 1 HFT, BG 1052 AVT 1 HFT, BGD 72 AVT 2, BS4, BGD 75 AVT 1 LS,BGD 81 AVT1K, BGD82AVTD, C-235, FG22, FG243, FG444, FG454, FG477, GCP-101CZ-O, GCP-101SZ, GCP-102, GCP-103IVT, GCP-104IVT,GOCG92228, GL90236, GL93011, GL 94008, GL94037, GL94041, GL94057, GNG469, GNG663, GNG737, GNGN978, GNG1000, GNG1005, GNG1046, GNG1078, GNG1093, GNG1107, GNG 1109, GNG1128, GNG 1130, GNG11137, GNG 1141, GNG 1166, GPF2CH, H-82-2CH, H92,67AVT1D, H92-97IVTL, H92-71IVTL, H93-10, H93-106, H93-106IVT-D, H208CH, H.K.93-88, H.K.92-122, ICCV10CZ, ICCV91130, ICP92-2, ICP95-IVTLATE, PVG10, PG92-4, Phule G8CH AVT CZSZIVTB, Phule G41AVT2DCZ, Phule G89224IVTBA.Z,

Phule G92007IVTBA.Z, Phule G92028AVT1BCZ-SH, EMG161BT-DESI, PUSA256 AVT1BS, RSG585M RSG617, H.K.92-94(RSG625), RSG 628K, RSG655, RSG798, RSG799, SAKI 93130 AVT2BCZ, DAKI9328 AVT1NHZ, SAKI 9513, SAKI 1916NIC, WCG3IVTB.

Resistant (R) BG256AVT1HFT79, BG1048AVT1K,BG1053AVT1K,BGD80AVT 1K, GF133, GICG91108, GICG92112, GL92162, GL93014, GL94019, GL 94023, GL 94056, GNG 1103, GNG 1118, GNG 1149IETB, H92-73IVT(D), Phule G8506-7AVT2 All zones NWPZ, NEPZ, SAKI 93130AVT2BNEPZ, VIJAY CHA AVT1,AVT2.

Susceptible (S)-15 BG 391 AVT 1B-5 BGDAVT1BS, H91-40AVT-20, JG22AVT1NHZ, L550, PB95IVT, PG92-2, Phule G8404-1 AVT1DNHZ, PMG12IVTB, PUSA 256 AVT 2BS, RSG551, RSG 553, WCG21VT LATE, WCG4-11VTLATE, WCG10 AVT2 DESI NWPZ.

Highly Susceptible (H.S.)1 PUSA 372 AVTI LS, - on the nematode population per gram of root at 45 DAS (days after sowing) the 124 varieties of chickpea were screened out and categorized into four categories as highly resistant, resistant, susceptible and highly susceptible. The results of screening of chickpea varieties are as under :

(i)	Highly Resistant (HR)	=	89
(ii)	Resistant (varieties)	=	19
(iii)	Susceptible (varieties)	=	15
(iv)	High susceptible ((varieties)=		1

Table 26 . Screening of chickpea varieties against *Pratylenchus thornei* (Farmer field experiment)

S.No.	Name of variety	Nematode population/g root	Rating
1.	BG 256 AVT 1HFT79	40	R
2.	BG 267 AVT 1K	22	HR
3.	BG 362 AVT 1BS	11	HR
4.	BG 390 AVT 1B	00	HR
5.	BG 391 AVT 2 B-5	00	HR
6.	BG 391 AVT 1B-5	82	S
7.	BG 1027 AVT, K	11	HR
8.	BG 1033 AVT, CS	17	HR
9.	BG 1035 AVT, LS	08	HR
10.	BG 256 AVT, BS	00	HR
11.	BG 1039 AVT2 HFT	05	HR
12.	BG 1043 AVT1 D	25	HR
13.	BG 1044 AVT1 BS	18	HR
14.	BG 1045 AVT1 BS	00	HR
15.	BG 1047 AVT1 LS	18	HR
16.	BG 1048 AVT1 K	38	R
17.	BS 1051 AVT1 HFT	20	HR
18.	BG 1052 AVT1 HFT	24	HR
19.	BG 1053 AVT1 K	34	R
20.	BGD 72 AVT2 BS4	14	HR
21.	BGD 75 AVT1 LS	31	HR
22.	BGD 81 AVT1 K	07	HR
23.	BGD 82 AVT D	353	HR
24.	BGD AVT1 BS	73	S
25.	BGD 80 AVT1 K	40	R
26.	C-235	19	HR
27.	FG 22	06	HR
28.	FG 343	13	HR
29.	FG 444	24	HR
30.	FG 454	18	HR
31.	FG 477	18	HR
32.	GCP-101 Cz-4	21	HR
33.	GCP-101 SZ	18	HR
34.	GCP-102	00	HR

35.	GCP-103 IVT	05	HR
36.	GCP-104 IVT	21	HR
37.	GF 133	29	R
38.	GICG 91108	30	R
39.	GICG 92112	50	R
40.	GICG 92228	12	HR
41.	GL 90236	13	HR
42.	GL 92162	27	R
43.	GL 93011	14	HR
44.	GL 93014	40	R
45.	GL 94008	25	HR
46.	GL 94019	32	R
47.	GL 94023	38	R
48.	GL 94037	21	HR
49.	GL 94041	13	HR
50.	GL 94056	47	R
51.	GL 94057	16	HR
52.	GNG 469	07	HR
53.	GNG 663	20	HR
54.	GNG 737	11	HR
55.	GNG 978	14	HR
56.	GNG 1000	24	HR
57.	GNG 1005	17	HR
58.	GNG 1046	25	HR
59.	GNG 1078	17	HR
60.	GNG 1093	04	HR
61.	GNG 1103	39	R
62.	GNG 1107	15	HR
63.	GNG 1109	09	HR
64.	GNG 1118	28	R
65.	GNG 1128	05	HR
66.	GNG 1130	24	HR
67.	GNG 11137	08	HR
68.	GNG 1141	13	HR
69.	GNG 1149 IETB	26	R
70.	GNG 1166	09	HR
71.	GPF 2CH	09	HR
72.	H-82-2CH	24	HR

Contd. 3

73.	H 91-40 AVT-20	60	S
74.	H 92-67 AVT1 D	21	HR
75.	H 92-67 IVTL	11	HR
76.	H 92-71 IVTL	13	HR
77.	H 92-73 IVT (D)	29	R
78.	H 93-10	12	HR
79.	H 93-106	07	HR
80.	H 93-106 IVT-D	09	HR
81.	H 208 CH	04	HR
82.	H.K. 93-88	20	HR
83.	H.K. 92-122	14	HR
84.	ICCV 10CZ	07	HR
85.	ICCV 91130	11	HR
86.	ICP 92-2	25	HR
87.	ICP 95-IVT LATE	10	HR
88.	JG 22 AVT1 NHZ	158	S
89.	L 550	57	S
90.	PB 95 IVT	75	S
91.	PBG 10	11	HR
92.	PG 92-2	150	S
93.	PG 92-4	05	HR
94.	Phule G8 CH AVT CZSZIVTB	12	HR
95.	Phule G 41 AVT2 DCZ	11	HR
96.	Phule G8404-1 AVT1 DNHZ	53	S
97.	Phule G8506-7 AVT2 ALL ZONES NWPZ, NEPZ	47	R
98.	Phule G 89224 IVTBA.Z	14	HR
99.	Phule G 92007 IVTBA.Z	08	HR
100.	Phule G 92028 AVT1BCZ-SZ	21	HR
101.	PMG 12 IVT B	76	S
102.	PMG 16 IVT DESI	13	HR
103.	PUSA 256 AVT2 BS	100	S
104.	PUSA 256 AVT1 BS	25	HR
105.	PUSA 372 AVT1 LS	264	HS
106.	RSG 551	107	S
107.	RSG 553	150	S
108.	RSG 585	21	HR
109.	RSG 617	12	HR

Contd. 4

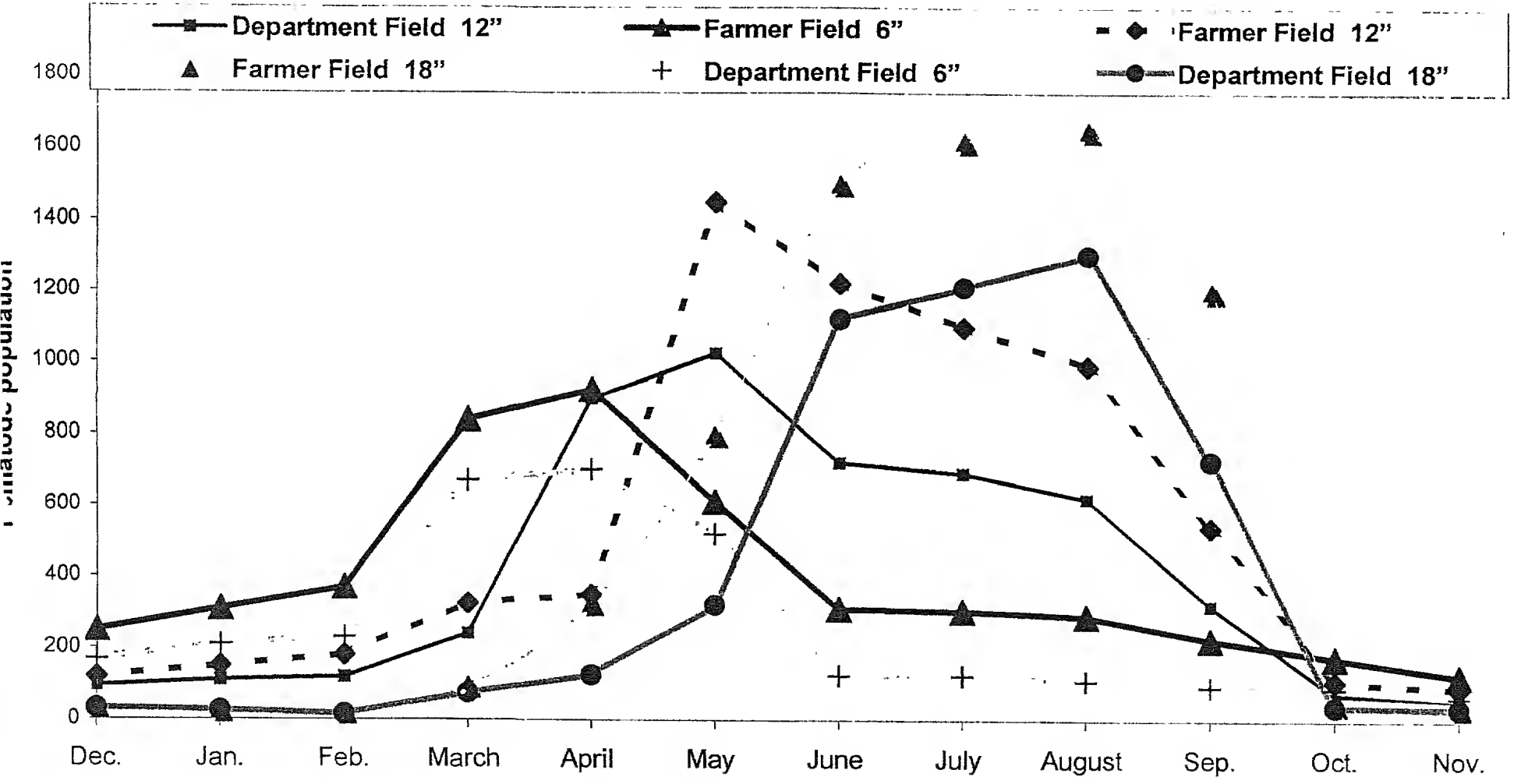
110.	H.K. 92-94 (RSG 625)	16	HR
111.	RSG 628 K	20	HR
112.	RSG 655	23	HR
113.	RSG 798	25	HR
114.	RSG 799	00	HR
115.	SAKI 93130 AVT2BNEPZ	50	R
116.	SAKI 93130 AVT2 BCZ	11	HR
117.	DAKI 9328 AVT1 NHZ	00	HR
118.	SAKI 9513	21	HR
119.	SAKI 9516 NIC	07	HR
120.	VIJAY CH AVT1, AVT2	50	R
121.	WCG 2IVT LATE	170	S
122.	WCG 3IVTB	15	HR
123.	WCG 4-1 IVT LATE	63	S
124.	WCG 10 AVT2 DESI NWPZ	153	S

Scale for rating: 0-25 = HR; 26-50 = R; 51-200 = S; > 200 = HS

Table- 27 Seasonal fluctuation and depth wise distribution of *Pratylenchus thornei* population in infested chickpea fields (1996-97)

Month	Farmer Field			Department Field		
	6"	12"	18"	6"	12"	18"
October	125	90	50	95	60	40
November	175	110	40	125	75	35
December	250	120	35	168	95	30
January	310	150	25	210	110	25
February	370	180	20	230	120	15
March	840	350	95	670	240	75
April	925	325	325	700	900	125
May	610	1450	798	520	1025	320
June	310	1220	1500	125	720	1120
July	305	1098	1620	110	690	1210
August	290	990	1650	90	620	1300
September	225	540	1200	65	320	725

Graph 26: Seasonal fluctuation and depth wise distribution of *Pratylenchus thornei* population in infested chickpea fields (1996-97)



8. Seasonal fluctuation and depth wise distribution of *Pratylenchus thornei* population in infected chickpea field

Year 1996-97 (Table 27) Graph-26

The effect of seasonal fluctuation on population of *Pratylenchus thornei* was recorded by studying the nematode population per calendar month during one year (1996-97) period at 6", 12" and 18" depth starting from December which corresponds with sowing season for chickpea under Allahabad conditions, in naturally infested and artificially (infested) developed sick plot with *Pratylenchus thornei* during *rabi* season. The results of these studies are included in the Table 27.

Infested field:

The farmer's and institute field was under the crop rotation sequence of chickpea – moong – til during one year observation period from Dec. 1996 to Nov. 1997 at different stages.

A. At 6" depth

(i) Farmer's field

The population of *Pratylenchus thornei* per 500 gm soil was 125 nematode at depth of 6 inch of soil in the month of Oct. and started increasing progressively till April when 925 nematode per 500 gm of soil were recorded. The population started declining gradually from April (925) nematode to Sept.. (225) nematode.

(ii) Departmental field

The population of *Pratylenchus thornei* per 500 gm soil was 95 nematode at depth of 6 inch of soil in the month of Oct. and started increasing progressively till

April when 700 nematode per 500 gm of soil recorded. The population started declining gradually from April (700 nematode) to Sept. (65 nematode).

B. At 12" depth

(i) Farmer's field :

The population of *Pratylenchus thornei* in the month of Oct. was 90 nematode/500 gm soil and started increasing till the month of May where 1450 nematode/500 gm soil recorded. The population started declining from the month of May 1450 nematode to Sept. (540 nematode).

(ii) Departmental field :

At the depth of 12 inches the population of *Pratylenchus thornei* in the month of Oct. was 60 nematode/500 gm soil and started increasing till the month of May when 1025 nematode from the month of May (1025 nematode) to Sept. (320 nematode).

C. At 18" depth

(i) Farmer's field :

The nematode population/500 gm soil was 50 nematode in the month of Oct. and started declined gradually till February when it was recorded 20 nematode and then the population of nematodes/500 gm soil started increasing gradually from Feb. (20 nematodes) to August (1650 nematodes) and then declined to 1200 nematodes in Sept. 97.

(ii) Departmental field :

The nematode population/500 gm soil was 40 nematodes gradually till February when it was recorded 75 nematode and then the population of nematode 1500 gm soil started increasing gradually from Feb. to August (1300 nematodes) and then declined to 725 nematodes to 35 Nematodes in Sept. 1997.

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CHAPTER -5

DISCUSSION

CHAPTER-V

DISCUSSION

Survey was conducted to find out prevalence of *Pratylenchus thornei* in two blocks Karchanna and Dandi of Allahabad district causing lesion nematode disease in chickpea crop. The soil samples of different crop from various village showed that there was a great variation in population of *Pratylenchus thornei.*

Field symptoms

All the observations revealed wide spread infestation of chickpea crop in the area surveyed, besides these infested plants indicated that *Pratylenchus thornei* was an important pathogen on chickpea. **Sharma *et al.* (1984)** also surveyed Aligarh and Mathura districts of U.P. and found moderate to high population of *Pratylenchus spp.* **Ali (1994)** also found *Pratylenchus spp.* in Nalanda district of Bihar in his survey thus these reports conformed our results for Allahabad area.

Pathogenicity trial with different inoculum level of *Pratylenchus thornei* per pot indicated reduction in the plant growth in inverse relation to initial inoculum, shoot length at harvest stages. Shoot and root weight were also reduced in nematode (*Pratylenchus thornei*) inoculated plants compared to uninoculated chickpea. In agreement of present study, some workers have also been reported the reduction in plant growth infested with nematode population on per gm of root and root system in chickpea crop due to *Pratylenchus thornei.* **Walia and Seshadri (1985)** with

chickpea, **Sethi and Swarup (1971)** with wheat, **Tiyagi and Praveen (1992)** with chickpea and **Sebastian and Gupta (1993)** with chickpea, have reported *Pratylenchus thornei* infection to be associated with reduction host growth of respective crop in India. The results obtained in our experiment are in confirmity with these reports. The rate of nematode multiplication as judged by total population per root system was found inversely proportional to initial inoculum level in present study.

This has been observed by **Walia (1982)** for *Pratylenchus thornei;* **Sharma and Sethi (1915)** and **Devi and Gupta (1988)** for *Heterodera cajani* on pigeonpea, **Apple and Lewis (1984)** and **Akhtar and Farzena (1989)** for *Meloidogyne incognita.* In our studies, with initial inoculum level of 500 and 1000 nematodes per pot, the final population was recorded 1.2 and 2.6 times, respectively. This confirm the results of earlier investigators.

Carbofuran and phorate at 0.2 g a.i./m^2 were evaluated against *Pratylenchus thornei* on chickpea in laboratory pot experiment, to recorded the plant growth parameters. All the two nematicides increased shoot length at 30, 60 and 90 DAS and shoot and root weight at 90 DAS. The results obtained in our studies indicated that carbofuran and phorate reduced the population of *Pratylenchus thornei* per root system as well as per gram of root, compared to untreated nematode inoculated plants. Phorate and carbofuran were equally effective against *Pratylenchus thornei* in reducing the nematode population but not the same degree. Reduction in

Pratylenchus thornei population on chickpea with the application of carbofuran (as soil treatment) has been reported by **Walia and Seshadri (1985).** Increased grain yield and reduced *Pratylenchus thornei* population as a result of carbofuran soil treatment were observed on wheat by **Sethi and Swaroop (1971). Ramkrishnan and Vadivelu (1995)** reported that carbofuran 3G at 0.75 kg a.i./ha was most effective against *Pratylenchus spp.* on Chrysanthemum. It is seen that phorate and carbofuran were quite effective in reducing the *Pratylenchus thornei* population in chickpea and the treated plants showed a corresponding increase in the various plant growth parameters compared to untreated check.

As a follow up of pot experiment a crop loss trial using carbofuran and phorate at 0.2 g a.i./m^2 was conducted in *Pratylenchus thornei* infested farmer field. Observation on shoot length and shoot & root weight at 45, 75, 90 and 105 DAS, the *Pratylenchus thornei* population per gram of root and per 500 g of soil at 30, 45, 60, 90, 120 DAS were recorded. An increase in plant growth as judged by various plant growth parameters at various stages, was recorded in carbofuran and phorate treated plants. The number of nematodes in roots and in soil was much reduced with the application of both these chemicals, but phorate showing better effect in this respect compared to carbofuran. The results of the field experiment were in general agreement with those obtained in the pot trial discussed above and with reports of earlier workers. This experiment further confirms the efficacy of application phorate and carbofuran in controlling *Pratylenchus thornei* infection on chickpea.

The number of nodules and weight per 10 nodules after 45, 75, 105 DAS on chickpea grown in *Pratylenchus thornei* infested field was increased by application of phorate while no adverse or favourable effect of carbofuran application in this regard was observed in our studies. **Nirmal *et al.* (1977)** have reported no effect of carbofuran and thimet on soil rhizobium population in gram. **Gawaad *et al.* (1972)** have reported increased root nodulation with the application of phorate. **Mishra and Gupta (1991)** recorded that furadan and phorate application increased the nodules and nodules weight of soybean. Our results are in general agreement with that of **Gawaad *et al.* (1972)** and in partial agreement with that of **Mishra and Gupta** (1997) and **Nirmal *et al.* (1977)** as we have also observed increased number of nodules with phorate.

Use of oil cakes as organic amendments in soil has been advocated in controlling the plant parasitic nematodes by some earlier workers **(Patel *et al.*, 1985, Alam and Ashraf, 1986; Sunderaraju and Koshy, 1986; Singh *et al.*, 1988; Schaver-Blume, 1988; Acharya and Padhi, 1989; Sen and Dasgupta, 1989; Devi, 1989; Patel and Thaker, 1989; Darekar and Mhase, 1990; Gul *et al.*, 1990 and Jonathan *et al.*, 1990).** In our studies, effect of soil amendment with Neem, Mahua, mustard, linseed, cakes in pot experiment and Neem, soybean, Mahua, linseed, mustard cakes in field experiment was studied against *Pratylenchus thornei* on chickpea. Observations were recorded in these trials on *Pratylenchus thornei* population (in roots and soil) and various plant growth parameters and

number of nodules and weight per 10 nodules per plant of chickpea. The results of pot experiment indicated that all oil cakes were effective in reducing *Pratylenchus thornei* population per root system and per gram of root compared to control. Neem cake was most effective in reducing the nematode population compared to linseed, Mahua and mustard and all others being equal in this respect. Plant growth parameters recorded in the present experiment showed a general increase with various oil cakes compared to control, with the maximum growth being recorded in Neem and linseed followed by others. **Siddiqui *et al.* (1976)** with Neem mustard and castor against *Tylenchorhynchus brassicae* on cabbage and cauliflower; **Zaiyed (1977)** with mustard linseed and castor cakes against *Meloidogyne javanica* on okra; **Patel *et al.* (1985)** with mustard cake against root knot nematode on okra; **Jain and Hasan (1986)** with Neem cake against nematodes associated with oat and cowpea. **Schaver-Blume (1988)** with deoiled crushed seeds of Neem against *Pratylenchus penetranes* on winter wheat; **Acharya and Padhi (1989)** with Neem cake against *Meloidogyne incognita* on betelvine; **Devi (1989)** with linseed Mahua, mustard, castor and Neem cakes against *Heterodera cajani* on cowpea; **Novaretti *et al.* (1989)** with compost against *Pratylenchus zeae* on sugarcane; **Patel and Thaker (1989)** with dry azolla and mustard cake against *Tylenchorhynchus vulgaris* on wheat; **Darekar and Mhase (1990)** with Neem cake against *Meloidogyne incognita, Rotylenchules reniformis* and *Xiphinema insigne* on grapevine and **Jonathan *et al.* (1990)** with press mud filter cake from cane sugar manufacturer and

Neem cake against *Meloidogyne incognita, Pratylenchus coffeae* and *Helicotylenchus dihystera* on sugarcane. **Khan (1992)** the effect of crushed dry Neem (*Azadirachta indica*) leaves at 833 or 1666 kg/ha on *Pratylenchus thornei* and the growth parameters of 3 wheat varieties.

Khan *et al.* (1994) reported that leaf extracts of *Azadirachta indica on* tobacco decreased the population density of *Pratylenchus thornei* in soil on wheat crop; **Sebastian and Gupta (1996)** evaluated effect of groundnut, linseed, mustard and Neem (*Azadirachta indica*) oilseed cakes for control of *Pratylenchus thornei* on chickpea in field trials in India and **Shukla and Hasub (1996)** evaluated effect of some oil cakes linseed (*Linum usitatissimum*), mustard (*Brassica compestris*), Neem (*Azadirachta indica*) were applied against *Pratylenchus thornei* infesting *Mentha citrata* and reported increased, plant growth of the respective crops. The results obtained in our studies against *Pratylenchus thornei* are in general agreement with reports of above workers.

Linseed, mustard, Mahua, soybean and Neem cakes were applied against *Pratylenchus thornei* infested micro-plots to further study & their efficacy against this nematode on chickpea under field condition was studied. The results indicate reduction in root (total and per gram population) and soil population of nematode with application of all oil cakes compared to control with corresponding increase in plant growth parameters at all stages. It was further observed that Neem and mustard cake were most effective in reducing nematode population as compared to

soybean, linseed and Mahua which were equally effective in this regard. Soil population of *Pratylenchus thornei* in oil cakes amended plots was much reduced compared to control with all cakes being equally effective.

Effect of cropping pattern: intercropping and mixed cropping in managing *Pratylenchus thornei* population on chickpea was studied in field trial. It was observed from results of field experiment that plant growth, growth parameters shoot length, shoot weight, root weight as number of nodules and weight per 10 nodules after 45, 75, 90, 105 days of sowing provided maximum 47.50 and 40.589 cm shoot length on chickpea + pea cropping pattern while minimum shoot length 33.73, 38.83 cm recorded in control in both the years. The maximum shoot weight (4.70) per two plants was obtained from the cropping pattern. Chickpea + wheat followed by chickpea + pea in mixed cropping in 1995-96. The cropping pattern of chickpea + wheat in the year 1996-97-98 produced maximum shoot weight 39.98 and 20.79 gm per two plants as compared to 35.39 and 20.25 gm respectively.

The cropping pattern of chickpea + wheat provided maximum root weight, 2.98, 4.00 and 2.68 gm per two plant as compared to 1.35, 3.08, 1.45 gm in control in the year 1995-96-97-98, respectively. The cropping pattern chickpea + wheat minimised the nematode population 195, 16 and 57, followed by chickpea + linseed, 199; 18, 57, nematodes per 500 gm soil in respective three years as compared to maximum 221, 35, 87, nematode population per 500 gm soil respectively.

The cropping pattern chickpea + wheat minimised the nematode population 41, 19 and 146 followed by chickpea + linseed 54, 19, 146 nematode per root system in respective three years as compared to maximum 83, 39, 226, nematode population per gm roots respectively.

The chickpea + wheat cropping system supported maximum number of nodules 59.67, 40.63, 24.25 per two plants followed by chickpea + pea, 57.83, 39.58, and 24.13 nodules per two plants in the years of experimentation as compared to control by supporting minimum 50.33, 33.08, and 20.21 number of nodules per two plants.

The cropping pattern chickpea + wheat supported maximum nodules 220.00, 328.75, 035 mg per two plant followed by chickpea + pea 216.00, 312.08, 0.33 mg per two plant nodules in the years of experimentation as compared to control by providing minimum 190.00, 262.92, 0.29 mg per two plants. **Heide (1975)** effect of crop rotation and concentration in nematodes population dynamics. The present situation is assessed and migrating root feeding nematodes. **Prasad and Rao (1979)** studied effect of mixed cropping using mung bean (*Phaseolus spp.*) and groundnu (*Arachis hypogeae*), with rice (*Oryza sativa*) and ragi (*Eleusine coracana*) o population of *Pratylenchus indicus, Hoplolaimus indicus, Tylenchorynchus spp.* an *Helicotylenchus spp.* **Ambrogioni *et al.* (1990)** studied the effects of the followin cropping pattern: Wheat and hard wheat intercropped with soybean and bienni rotations of sugarbeet-wheat, sorghum-wheat, and sunflower-wheat when nematod

extraction from soil samples showed *Pratylenchus neglecta* to a lesser extent and *Pratylenchus thornei* to be the most numerous. Their number always increasing after a wheat crop, as did those of *Pratylenchus spp.* **Greco and Sharma (1990).**

In the present studies, 124 varieties of chickpea were screened against *Pratylenchus thornei* in a field experiment. The varieties were graded as highly resistant (HR), resistant (R), susceptible (S), highly susceptible (HS), based on total population of nematode per gm of root. 89 varieties of chickpea were found highly resistant, 19 resistant, 15 susceptible and 1 highly susceptible. In agreement of our results, **Tawnshed (1990)** has also suggested that the ability of nematode to reproduce in host should be taken as the method for evaluating plant resistant to *Pratylenchus spp.* **Walia (1982)** recorded that chickpea variety L-555 was less susceptible to *Pratylenchus thornei* in our study the same.

The results of seasonal fluctuation on population of *Pratylenchus thornei* were recorded at 6", 12" and 18" depth of soil, Starting from October on chickpea under Allahabad condition in naturally and artificially infested sick plot of *Pratylenchus thornei* during *rabi* season.

The result of population fluctuation of *Pratylenchus thornei* at 6" depth per 500 gm of soil started declining gradually from April (925) and September (225) nematode in the farmers field while the population in departmental field in April (700 nematode) to September (65 nematode).

The result of 12" depth of per 500 gm of soil showed population fluctuation of *Pratylenchus thornei* that gradually declining from the month of May to September (540) nematode in the farmers field, while (1025) nematode in May and (320) nematodes in September were recorded in departmental field.

The result of population fluctuation *Pratylenchus thornei* at 18" depth per 500 gm of soil started increasing gradually from February (20) nematode to August (1650) nematode and then declined to (1200) nematodes in September in farmers field, while (75) nematodes from February to August (1300) nematodes and then declined to (725) September in departmental field. Our results are similar to the result of **Maassen (1997)** who found an increased population of *Pratylenchus spp* in soil by the onset of root decay of host plant and a tendency of nematode to leave the roots and migrate into soil. The report of **Dayal *et al.* (1987)** reported that *Pratylenchus thornei* can migrate to a depth of 120 cm in soil as a mean of survival during unfavourable condition or as per the reports of **Glazer and Orion (1983)** who observed that all stages of *Pratylenchus thornei* are undergoing on hydrobiosis in a coiled form to withstand unfavorable off season.

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CHAPTER -6

SUMMARY AND CONCLUSION

CHAPTER-VI

SUMMARY AND CONCLUSION

Survey was conducted to find the prevalence of *Pratylenchus thornei* in two blocks Karchanna and Dandi of Allahabad district, causing lesion nematode disease in chickpea crop. The soil samples of different crop and various villages showed that there was a variation in population of *Pratylenchus thornei* in field. All these observations revealed wide spread infestation of chickpea crop in the area surveyed. Besides, the symptoms observed on infested plant indicated that *Pratylenchus thornei* was as important pathogen on chickpea.

The shoot and root weight were reduced in *Pratylenchus thornei* inoculated plants as compared to uninoculated plants of chickpea at various stages of the crop. The soil application of Carbofuran 3G and phorate 10 G were equally effective in reducing the population of *Pratylenchus thornei* per root system as well as per g of root as compared to untreated check on chickpea crop.

The number of nematodes in roots and soils were also much reduced with the application of phorate and carbofuran which also resulted in increased plant growth of chickpea at various stages of crop. While the number of nodules and weight of 10 nodules at various intervals were increased by application of phorate but carbofuran showed neutral effect on nodules and nodules weight.

The results of pot experiment showed that Neem cake was most effective in reducing the nematode population followed by linseed, Mahua and mustard cake as

compared to control. Maximum growth of plants was recorded in Neem and linseed cake treated plants of chickpea.

The observations of field experiment showed that soil application of Neem and mustard cake were most effective in reducing the nematode population in per gm of root and per 500 gm of soil. The soybean, linseed and Mahua cake were equally effective in decreasing the nematodes as compared to control on chickpea crop. As a results of these above cakes also increased the plant growth.

The maximum shoot length obtained from chickpea + pea cropping pattern while minimum shoot length recorded in control at various stages and intervals of crops in both the years. The least shoot weight/two plants was obtained from the cropping pattern chickpea + wheat followed by chickpea + pea in mixed cropping, while the maximum shoot weight was recorded in chickpea + wheat intercropping.

The cropping pattern of chickpea + wheat provided maximum root weight/two plants as compared to control in all the years of experiments. The cropping pattern chickpea + wheat was also minimized, the nematode population followed by chickpea + linseed/500 gms of soil and per gm of roots in respective three years.

The cropping system chickpea + wheat supported maximum number of nodules and weight of nodules per two plants followed by chickpea + pea as compared to control in respective three years in chickpea crop.

The population fluctuation of *Pratylenchus thornei* gradually declining from April, May and Sept. in farmers field as well as in departmental field at 6" and 12" depth of per 500 gms soil. The results on population fluctuation at 18" depth/500 soils, increasing gradually from Feb. to Aug. and then declined from Sept. in farmers field as well as in departmental fields.

The results of varietal screening of chickpea showed that 87 varieties were found highly resistant, 20 resistant, 15 susceptible and 2 highly susceptible to *Pratylenchus thornei.*

CONCLUSION

The results show that the shoot and root weight reduces in *Pratylenchus thornei* inoculated plants, while the application of carbofuran and phorate reduced the population per root system and per g of root as compared to check on chickpea crop. The application of phorate also reduced the number of nematode population in roots and soil and increases the number of nodules and weight of nodules, while carbofuran increases the plant growth at various stages of crop.

The results concluded in pot experiment showed that Neem cake was most effective in reducing nematode population and increasing plant growth followed by linseed, while the Neem and mustard cakes reduce nematode population per g of root and 500 g of soil and increased the plant growth in field conditions.

The cropping pattern chickpea + wheat showed maximum shoot length, shoot and root weight, reduction in nematode population and maximum number of nodules and weight of nodules as compared to other cropping pattern in all the three years.

The fluctuation showed that population gradually declining from April-May and Nov. at 6" and 12" depth and increasing from Feb. to August and declined to Nov. in the farmers field as well as departmental fields.

In varietal trial, 89 varieties were found highly resistant, 19 resistant, 15 susceptible and 1 highly susceptible to *Pratylenchus thornei.*

REFERENCES

REFERENCES

Abawi, G.S.; Crosier, D.C. (1983 Pub. 1984). Efficiency of Oxamyl and Aldicrab against the nematicide test. Ann. Phytopathol. Soc., 39: 88.

Abd-Elgawad, M.M. and Saad, F.F. (1989). Nematode population dynamics on common bean as affected by intercropping with maize. Beitraage zur Tropischen Land Wirtschoft and Veterinarmedizin 27 (4); 443-448.

Abranted, I.M. Deo; Faria, C.A.T. De and Santos M.S.N. De. (1987). Root lesion nematode (*Pratylenchus* spp.) in Portugal. Nematologia Mediterranea, 15 (2): 375-378.

Acharya, A and Padhi, N.N. (1988). Effect of Neem oil-cake and sawdust against root-knot nematode *Meloidogyne incognita* on betel vine. Indian J. Nematol. 18 (1) : 105- 106

Acosta, M. (1982). Susceptibility of soyabean cultivars to *Pratylenchus scribneri* and *Meloidogyne incognito* Nematropica, 4:96

Acosta, N. (1982) Vertical distribution of *Pratylenchus alleni* and *P. scribneri* in soyabean root. J. Agr. Univ. Puerti Rico, 66 (1) : 60-64.

Ahmed, S.; Khan, A.A. and Khan, S. (1987). Pathogenicity of reniform nematodes, *Rotylenchulus reniformus* on chickpea. Newsl., 16 : 8-9.

Akhtar Haseed and Farzana Butool (1989). Pathogenicity and reproduction of *Meloidogyne incognita* on *Ocimum sanctum. Intl.* Nematol Network News letter., 6 (4) : 27-30.

Alam, M.M. and Ashraf, S. (1986). Soil population of plant parasitic nematode infecting *Trificale hexaploide* as influenced by organic soil amendments and nematicides. Intl. Nematol. Network Newsl., 3 (1) : 19-20.

Alam, M.M. and Khan, A.M. (1974). Control of phytonematode with oil-cake amendments in spinach field. Indian J. Nematol, 4 : 239-240.

Alam, M.M.; Khan, A.M. and Saxena, S.K. (1978). Mechanism of control of plant parasitic nematodes as a result of the application of organic amendments to the soil. IV- Role of formaldehyde and acetone. Indian J. Nematol., 8 : 172 – 174.

Alam, M.M.; Khan, A.M. and Saxena, S.K. (1979). Publ. (1980). Mechanism of control of plant parasitic nematodes as a result of the application of organic amendments to the soil, V-Role of phenolic compounds. Indian J. Nematol. 9 (2) : 136-142.

Ali. S.S. (1987). Investigations on plant parasitic nematode associated with pulse crop. In Ann. Rep. 1987. DTE of Pulse Res.; Indian Council of Agric. Res. Kanpur 127 – 128.

Ali. S.S. (1990). Investigation on plant parasitic nematode associated with pulse crops. In App. Rep. 1989 – 90. DTE of Pulse Res.; Indian Council of Agric. Res. Kanpur, 73- 79.

Ali, S.S. (1991). Consolidated report on rabi pulses, 1990-91. Plant Nematology. All Indian Co- ordinated Pulse Improvement Project (ICAR), Rabi pulse group meet, Sept. 26-28, 1991, Marathwada Agric. University, Parbhani, 44 PP.

Ali. S.S. (1992). Consolidated Report on Rabi Pulses, 1991-92. Plant Nematology. All Indian Co- ordinated pulse improvement project (ICAR), Rabi pulse group meet, Sept. 21-23, 1992,C.C.S. Haryana Agric. University, Hissar (Haryana), 48 PP.

Ali. S.S. (1993). Prevalence of plant parasitic nematodes associated with chickpea in Gwalior district of Madhya Pradesh, Int. Chickpea Newsl. 28 :11.

Ali. S.S. (1993). Consolidated report on rabi pulses, 1992- 93. Plant Nematology. All Indian Co- ordinated pulse improvement project (ICAR),

Rabi pulse group meet, Sept. 8 – 10, 1993, Univ. Agric, Sc., Banglore, Karantaka. 46 PP.

Ali, S.S. (1994). Consolidated report on rabi pulses, 1993- 94. Plant Nematology. All Indian Co- ordinated pulse improvement project (ICAR), Rabi pulse group meet, Sept. 15 – 18, 1994, Rajsathan Agric. Univ, Bikaner, Rajasthan. 61 PP.

Ambrogioni, L; Caroppo, S. and Marinari, A. (1990) Crop rotation effect on cereal Nematode population. Annali. Dell Intituto-sperimentale-Agronmica-di-bari, 21 suppl. 2-44-45.

Anonymous, (1985). All India Co-ordinated Research Project on Nematode pests of crops and their control Biennial Consolidated report 1983-85. Indian Agricultural Research Institute New Delhi- 78 PP.

Anonymous, (1987). All India Co-ordinated Research Project on Plant Parasitic Nematodes with Integrated Approach for their control, Proceedings of the workshop. College of Agriculture. Pune, Mahatma Phule Agric. Univ. Rahuri (Maharashtra). June 9 – 12, 128 PP.

Anonymous. (1989). All India Co-ordinated Research Project on Plant Parasitic Nematodes with Integrated Approach for their control.

Biennial Report (1987 – 88 to 1988- 89) Buibaneshwar Centre Deptt. Nematology, Orissa Univ. of Agric & Tech. Bhubaneshwar (Orissa) 43 PP.

Anver, S. and Alam, M.M. (1992). Prevalence of Plant parasitic nematodes associated with chickpea and pigeonpea in western Uttar Pradesh. Afro-Asian nematode. Network. 1:5-8.

Apple, J.A and Lewis, S.A. (1984). Pathogenicity and reproduction of *Hoplolaimus columbus* and *Meloidogyne incognita* on Devis. Soybean. J. Nematol. 16 : 348 – 355.

Atu, U.G. and Duru, N. (1990). Control of lesion nematode *Pratylenchus* brachyurus on late season sweet maize with Carbofuran. Beitragezur Tropischenlandwirtschaft and voterinairmedizin, 28 (1) : 69 – 73.

Azmi, M.I. (1984). Effect of *Pratylenchus zeae* on seeding growth of Suabool (*Leucaena leucocephala*) and its control with phorate. Nematologica. 30 (1) : 105 – 107.

Badra, T. and Shafiee, M.F. (1979). Effect of Nitrogen source and rate on the growth of lime seedling and the control of *Tylenchulus semiperetrans*. Nematologia Mediterranea, 7 (2) : 191-194.

Basigalup, D.H.; Barned, D.K.; Peterson, A.D. and Thies, J.A. (1988). Effect of *Pratylenchus penetrans* on nodulation and N_2 fixation in alfalfa clones. In Report of the thirty first North American Alfalfa Improvement conference held at Beltsvile, Maryland U.S.A. 19 – 23 June.

Bhatt, J. 1992. Pathogenic effect of *Pratylenchus thorei* (Filipjev, 1936) Sher and Allen; 1953 on the yield and protein in gram (*Cicer arietinum* L.) first Afro- Asian Nematology Symposium. Deptt. Botany; Aligrah Muslim university Aligarh, India Nov. 29, Dec., 3 (Abstr): 39PP.

Bhatnagar, A and Gupta, A (1991). Persistence of Carbofuran residues in soil Chickpea, News Letter, 24 : 31 – 32.

Bhatt, J. (1992) Effect of migratory nematode *Pratylenchus thornei* (Filipjev, 1936). Sher and Allen, 1953 on noduation in gram (*Cicer arietinum* L.) First Afro- Asian Nematology Symposium, Deptt. Botany, Aligrah Muslim University, Aligarh, Nov., 29, Dec., 3 (Abstr. 5)PP.

Chapman, R.A. (1959). Development of *Partylenchus pentrans* and *Tylenchorhychus martini* on red clover and alfalfa. Phytopathology, 49 : 357- 359.

Christie, J.R. and Perry, V.G. (1951). Removing nematodes from soil. Proc. Hel, Soc. Wash. 18 : 106 – 108.

Colbran, R.C. and McCulloch, J.S. (1965). Queensland J. Agr. And Ani. Sci., 22 : 253-356.

Cook, R.J.; Boosalis, N.C. and Doupink, B. (1978). Influence of Crop residues on plant disases. 1. Crop Residue Management Systems, PP. 147-163, Agronomy Sos. Am. Spec. publ. No. 131.

Carbett, D.C.M. (1969). *Pratylenchus pinguipandatus* n.sp. (Pratylenchinae; Nematoda) with a key to the genus *Pratylenchus.* Nematologica 15 : 550- 556.

Carbett, D.C.M. (1970). Cereal *Parthlenchus* spp. in England ed wales and their recognition. Pl. Patho. 19 : 6 – 10.

Darekar, K.S. and Jaydele, G.B. 1987. Pathogenicity of *Rotylenchulus reniformis* to chickpea. Curr. Res. Reptr. Mahatma Phule Agric., University, 3 (2) : 89 – 92.

Darekar, K.S.; Mhase. N.L. (1990). Management of grape vine nematode in field with Neem cake and granular nematicide, Bioved 1 (1): 101-103.

Darekar; K.S.; Shele, S.S. and Mhase, N.L. (1990). Effect of placement of non-edible oilseed cakes on the control of root- knot nematodes on tomato. Int nema. Network Newsl., 70 (1) : 5 – 7.

Dasgupta, D. R. and Seshadri, A.R. (1971). Races of the reniform nematode. *Rotylenchulus reniformis* Linford and Oliveria, 1940. Indian. J. menatol. 1 : 21 – 24.

Das. S. and Das, S.N. (1985). Host range of *Partylenchus coffae* Indian J. Nematol. 16 : 180 – 184.

Davito (1991). Effect of the population of *Pratylenchus thorei* in plots treated with Aldicarb nematicide in Pea. Int. Nema. Network. Newsl. 25 (3) : 9 – 10.

D'Errico, F.P. (1970). Some plant parasitic nematodes found in Italy. Bollettino del laboratoria di entomologia Agraria filippo silvestri, Portici, 28 : 183 – 189.

Devi. S.L. and Gupta, P. (1988). Pathogenicity and management of *Heterodera cajani* on some pulse crops. Indian Phytopathol 41 (1) : 470 – 472.

Devi, S.L. (1989). Studies on cyst nematodes problems associated with some pluse crops of Allahabad Ph.D. thesis submitted to Allahabad Univesity, Allahabad.

Diamod, J.; Kimpiski, J. and Gallant, C.L. (1991). Root lesion and root- knot nematodes associated with crop grown in rotation with carrot on Prince Edward Island Can. Pl. Dis. Sur. 71 (1) : 13- 15.

Dickerson, O.J. and Franz, I.J. (1974). Resistance to *Pratylechus* spp. in dry edible beans and soybean (abs.) Proc. Am. Phytiopathol Soc., 1 : 125.

Divito, M.; Greeco, N. and Saxena, M.C. (1992). Pathogenicity of *Pratylenchus thornei* on chickpea in Syria. Nematol. Medit., 20 : 71 – 73.

Doyle, A.D.; Mclead, R.W.; Wong, P.T.W.; Hotherington, S.E. and Southwell, R.J. (1987). Evidence for the involvement of the root lesion nematode *Partylenchus thornei* in wheat yield decline in Northern New South Wales. Aus. J. Exp. Agr., 27 (4) : 563 – 570.

Duddington, C.L. and Duthoit, C.M.G. (1960). Green Manauring and cereal root eelworm. Pl. Pathol. 9 : 7 – 9.

Dussington, C.L. Everard Corand Duthoit, C.M.G. (1961). Effect of green manuring and predacious fungus on cereal root eelworm in oats. Pl. Pathol. 10 : 108 – 109.

Edongali, E.A. and EL. Malih, A.K.R.(1988). *Pratylenchus thornei* in almond in Libya. Intl. Nematode Network Newsl. 5 (3) : 44.

Edward, J.C.; Mishra, S.L.; Rai, B.B. and Peter, R. (1970). *Pratylenchus* spp. Associated with crops of the Allahabad Agricultural Institute campus, Allahabad Farmer, 44 : 107 – 110.

Elliott, A.P.; Smucker, A.J.M. and Bird, G.W. (1980). Agronomy abstracts 72nd annual meetings, American Society of Agronomy, 98 Michigan State University East Lansing, Ml 48823, U.S.A. Field Crop Abstracts 34 (9) : 7316.

Eissa, M.F.M. (1982). Control of *Pratylenchus thornei* parasitizing potato under field conditions of Saudi Arabia. Res. Bull Fac. Agr. Ainshams University, Cairo, No, 1742, 14 PP.

Eissa, M.F.M. and Monssa, F.F. (1982). Efficacy of some systemic nematicides on nematode population and yield of wheat in Nile – Delta with reference to a New Criterion, Nematistatic value, for

evaluation of nematode population characteristics. Res. Fac. Agr. Ainsham, Univ. cairo, No, 1741, 10 PP.

Esmenjaud, D; Rivoal, R. and Marzin, H. (1990). Number of *Partylenchus* spp. (Nematode) in the field on winter wheat in different cereal rotations. Nematologica 36 (2) : 217 – 226.

Fawale, B. and Maiw, F. (1988). Risk of rye as a cover crop in alternate planting with potato in *Pratylenchus penetrans* infested soil. Fit. Pathol. Bras 13 (4) : 346 – 348.

Gawaad, A.A.A.; Zaid, M. and El-Minshawy, A.M. (1972). Studies on soil insecticides in broad beans and Egyption alone nodule forming bacteria Zbl. Bakt. Abt. II. 127 : 290 – 295.

Gili, J.S. and Singh, R.V. (1990). Nematodes associated with pulse crops and their control. In progress in Plant Nematology (eds. Sexana, S.K.; Khan, W.N.; Abdul Rashid and Khan, R.M.) CBS published and Dustributor Pvt. Ltd. Delhi. 32 : 503- 514.

Glazer, I and Orion, D. (1983). Studies on anhydrobiosis of *Pratylenchus thornei* J. Nematol. 15 (3) : 333- 338.

Glazer, I and Orion, D. (1984). Influence of Urea, hydroxy- urea and thiourea on *Meloidogyne javanica* and infected excised tomato roots in culture, J. Nematol 16 (2) : 125-130.

Ganana Pragasam, N.C. (1982). Effect of Potassium fertiliztion and of soil temperature on the incidence and pathogencity of the root lesion nematode *Pratylenchus loosi.* Tea Quarterly 51 (4) : 169 – 174.

Ganana Pragasam, N.C. (1997). Effect of plant species having nematicidal properties against *Pratylenchus lossi. Radopholus similis* attacking tea in Srilanka. Tea Quarterly 71 (5) : 201- 206.

Gopal Pandey and K.P. Singh (1990). Effect of organic amendments on soil microflora and nematode fauna with special reference to *Meloidogyne incognita* in chickpea. New Agriculturist 1 (1) : 65 – 70.

Greco, N; Deivito, M. Reddy, M.V. and Saxena, M.C. (1984). A preliminary report of survey of plant parasitic nematodes of leguminous crops in Syria. Nematol. Medit, 12 : 87 – 93.

Greco, N.; Deivito, M and Nomda, G. (1992). The emergence of Juveniles of *Heterodera ciceri,* Nematropica. 38 : 514 – 519.

Greco, N; Divito, M. (1987). The importance of plant parasitic nematodes in food legume production in the Mediterranean region. In Nematode Parasitic to Cereals and Legumes in Temperate Semiarid Regions (Eds: Saxena, M.C.; Skiora, R.A. and Srivastava, J.P.) ICARDA, Syria. Proc. Workshop held at Larnaca, Cyprus Marcj 1-5, 28- 45.

Greco, N; Deivito, M; Reddy, M.V. and Saxena, M.C. (1988). Effect of *Heterodera ciceri* on yield of chickpea and lentil and development of this nematode in chickpea in Syria. Nematologica 34 (1) : 98 – 114.

Greco, N; Deivito, M; Reddy, M.V. and Saxena, M.C. (1988). Investigation on the root lesion nematodes *Pratylenchus thornei* in Syria. Nematol Medit. 16 (1) : 101- 105.

Greco, N. and Sharma, S.B. (1990). Progress and problems in the management of nematode disease in Chickpea in the nineties. Proc. Second Int. Workshop on Chickpea improvement ICRISAT Centre, Patancheru, India 135 – 137.

Green, C.D. and Dennis, E.B. (1981). An analysis of the variability in yield of pea crops attracted by *Heterodera goettingiana, Helecotylenchus vulgaris* and *Pratylenchus thornei* Pl. Pathol, 30 (2) : 64 – 71.

Gaul, A Saiiifullah and Shah, S.F.A. (1990). Control of root – knot nematodes in tomato through organic amendments and NPK. Sarsad, J. Agr.; 6 (1) : 95-97.

Gupta, P. (1996). Evaluation of some oil cakes against *Pratylenchus. thornei* on chickpea. Annual Pl. Prote. Sci.

Hashim, Z. (1979). A prelimibary report of the plant parasitic nematodes in Jordan. Nematol. Medit. 7 : 177 – 186.

Hashim, S and Hashim, G. (1989). Host status of several economic plants to *Pratylenchus zeae* from Pakistan. Nematropica 19 (2) : 195 – 197.

Heide : Plam (1972). Archiv- fur- acker- und Planzerbau-und-Boden Kunde 29 (7) : 321 – 329.

Heide, A (1973). Control of root gall nematode and migratory root nematode with reduced amount of nematin and Basamid Vertrage der 12, Tagunge uber problems der phytonematologie, Gross lusewitz. 1 June, 1973, 1973 – 85- 100 Gross Lusewitiz. Akademic der land wortscha ftswisserischaften der deutschen Republuic.

Heide, A. (1974). Control of root- knot nematode under glass house with reduced amount of Vapam and Dazomet. Nachrichten blatt-furden Pflanzencheutz – in- der. D.D.R. 28 (9) : 188 – 91, 7 ref.

Heide, A. (1975). Migratory root nematode as pest of cereals in crop rotation a survey. Archiv. Fur acker – und – pflanzenbau – und – boden. Kunde, 19 (5) : 383 – 393.

Heide, A. (1975). Studies on the population dynamics of migratory root nematodes in cereal mono cultures as well as in rotational cereal growing. Archive- fur- Phytopathologie- und- Pflanzenchurtz, 11 (3) : 225- 232.

Hussey, R.S. and Barker, K.R. (1974). Effect of nematodes with different feeding habits on nodulation of legumes (Abs) J. Nematol, 6 : 143.

ICARDA (International Centre for Agricultural Research in the Dry Areas) 1985b Studies on nematodes of food legumes. Progress Report 1984/85 food legume improvement program, ICARDA (International Center for Agricultural Research in the Dry Area) 1986. Studies on nematodes of food legumes. Progress report 1985/86. food legumes improvement program. ICARDA. Aleppo, Syria. 16 PP.

Ismail, W. and Saxena, S.K. (1977). Effect of different levels of potassium on the growth of root-knot nematode, *Melogiogyme in – cognita* on tomato, Nemtogica 23 (2) : 263 – 264.

Ivezic, M. and Samota, V. Raspudic, Harvet (1996). Newsl. Nemtol. 12, 182 – 185.

Jaehn, A; Monteiro, A.R.; Lordello, L.G.E; Barbim, D.; Demerio, C.G.B. (1983). Effect of N and K on infestation of coffee tree roots by *Meloidogyme incognita.* Intrabulos Apresentad a VIII Reuniao Brasileirode Nematologia, Brasilia Brasilesira de Nematologie 189- 208.

Jain, R.K. and Hasan, N. (1986). Association of Versicular Arbuscular My corrhizal Fungi and plant parasitic nematode with forage sorghum (Sorghum bicolor) Sorshum, Newsl. 29 : 84

Jain, R.K. and Hasan, N.C. (1986). Efficacy of neem cake on fodder production ,photosynthetic pigments and nematode associated with oats and its residue effects on cowpea. Indian J. Nematol. 16 (1) : 98 – 100.

Johnson, A.W.; Dowler, C.C. and Hauser, E.W. (1974). Seasonal population dynamics of selected plant parasitic nematodes on four non cultured crops. J. Nematol. 6 : 187 – 190.

Jonathan, E.I.; Krishanmoorthy, S.V.I Mandharan, M.L. and Muthukrishan, K. (1990). Effect of organic amendments on the control of sugarcane nematodes. Baratiya Sugra, 16 (6) : 39- 40.

Joshi, L.M.; Renfor, R.L.; Sarri, E.E.; Wilcoxson, R.D. and Ray Chaudhuri, S.R.(1970) Pl. Dis. Reprt. 54 : 596-595.

Juhl, M. (1981). The influence of increasing amount of nitrogen on the population of the cereal cyst nematode (*Heterodera avenea*). Tidssskrift for Palanitaevi, 85 (3): 281-289.

Kaliram and Gupta, D.C.(1980). A note on the efficacy of fresh neem leaf extract in the control of *Meloidogyne javanica* infecting Chickpea. Indian J. Nematol. 10 (1) : 96 – 98.

Kaushik, H,D, and Bajaj, H.K. (1980). Nematodes associated with pulse crops in Haryana. Indian J. Nematol. 10 : 92 – 96.

Khan, E and Wadhwa, S. (1969). Survey record of plant parasitic nematodes at Delhi and adjoining areas. All India Nematol Sym. New Delhi : 36 – 37.

Kahn, M.W.; Alam, M.W.; Khan, A.M. and Saxena, S.K. (1974). Effect of water soluble fractions of oil-cakes and bitter principles of neem on some fungi and nematodes. Acta Botanica Indica. 2 (2).

Khan , A; Rajput, T. and Bilqees, F.M. (1989). Influence of some fertilizers on plant parasitic nematodes. Pakistan J. Zool.

Khan, A. (1992). Effect of neem leaives and Cabofuran on *Pratylenchus thornei* associated with three wheat varieties. Pakistan, J. Scientific and Industrial Research 35 (11) : 459- 460. 14 ref.

Khan, A.; Shaukat, S.S.; Qamar, Fl Jeffery, A.H. and Harko, A.A. (1994). Effect of th free plant extract on nematode population and on growth parameters wheat (var. Pirsbak-85). Sarhad J. of Agric. 10 : 415 – 418. 15 ref.

Kinlocj, R.A. and Llutrick, M.C. (1975). The relative abundance of nematodes in an established field crop rotation. Proc. Soil and Crop. Sci. Sco. Florida, 34 : 192 – 194.

Koenning, S.R.; Schmith, D.P. and Barker, K.R. (1985). Influence of planting date on population dynamics and damage potential of *Partylenchus brachyurus* on soybean. J. Nematol. 17 (4) : 418- 434.

Koliopanos, C.N. and Kalyviotis- Gazelas, C. (1979). Nematodes and host plants identified for the first time in Greece. Ann. Inst. Phytopathol Benaki, 12 : 50 – 58.

Lamberti, F. (1981). Plant nematode problem in the Mediterranean region. Helm. Abs. Series B. 50 : 145- 166.

Lapinski, A. (1988). Fertilizer application to crops as a factor limiting harmful nematode populations. Chrona Roslin Poland 32 (8): 5-6.

Lordello, A.I.L.; Sawazaki, E; Lordello, R.R.A. and Aloisi Sobrinho, J (1985). Evaluation of Maize cultivars in an area infested with pratylenchus spp. at two sowing dates. Nematologia Brasilleira, 9 : 7-8 ept.

Luedders, V.D.; Shannon, J.G. and Baldwin, C.H. (1979). Influence of rate and source of potassium on soybean cyst nematode reproduction on soybean seedlings Pl. Dis. Reptr. 63 (7) : 558 – 560.

Maassen, H. (1977). Investigation of migration of Pratylenchu sp. into and out of maize roots in relation to taking of soil and root samples. Gesuude Pf lanzen, 29: 203- 205.

Magnifico, V. and Vovleas, N. (1975). Herbicidal and nematicidal products in the preparation of celery seed. Informatose Fitpatologiea, 25 (10) : 17 – 21.

Mahapatra, B.C. and Das, S.N. (1979). Host range and Pathogenicity of *Tylenchorhychus mashhoodi* Siddiqi and Basir, 1949 on maize

(Zea maydis). Nematology Symposium. Bhubabeshwar Orissa. March, 1979. Indian J. Nematol 9 (1) : 64.

Mahapatra, B.C. and Padhi, N.N. (1986). Pathogenicity and control of *Rotylenchulus reniformis* on *Cicer areitinum.* Nematol Medit 14 (2): 287 – 290.

Majed Al-Ahmad. (1987). The status of plant parasitic nematodes in cereals and food and forage legumes in Syria. In. Nematodes Parasitic to cereal and legumes in temperature semi- aid regions (eds. Saxena, M.C.; Sikora, R.A. and Srivastava, J.P.) ICARDA Syria. Proc. Workshop held at Larnaca Cyprus, March 1-5, 193-198.

Marull, J.; Pinochet, J. and Verdejo, S. (1990). Response of fine almod cultivars to four root lesion nematodes in Spain. Nematropica, 20 (2): 143 – 151.

Mishra, S.M. and Gupta, P. (1988). Sweet peas new host of *Pratylenchus thornei* in India. Indian J. Nematol. 18 (2) : 357.

Mishra, S.M. and Gupta, P. (1991). Chemical control of *Meloidogyne incognita* associated with soybean Current Nematology. 2 (2) : 145- 146.

Mojtahedi, H.; Santo, G.S. and Kraff, J.M. (1988). First report of *Pratylenchus thornei* on dry land wheat in Washington State. Pl. Dis., 72 (2) : 175.

Naganathan, T.G., Aru Mugam, R.; Kulasekaran, M.; Vadivelu, S.; (1988). Effect of Antagonistic crops as intercrops on the control of banana nematodes. South. Indian Horticulture 36 (5) 268- 269. 2 ref.

Nair, K.K.R. (1979). Studies on the chemical control of Banana Nematodes Agric. Res. J. of Kerala 17 (2) : 232-235 4 ref.

Nirmal, D.D.; Bhagwat, V.Y. and Ganacharya, N.M. (1977). Effect of some pesticides on *Rhizobium* Spp. nodulating gram (*Cicer aricetinum*) and *Azotobacter chrococcum* J. Maharashtra Agric. Univ. 2 (2): 186-188.

Novaretti, W.R.T.; Carderan, J.O.; Strabelli, J. and Amorim. E. (1989). Effect of Compost application alone or in combination with nematicide and fertilizers on nematode control and productivity of sugar cane. Nematologia Brasileria, 13 : 93 – 107.

Novaretti; W.R.T. and Nelli, E. J. (1989). New nematicide tests in Sugarcane, Boletin Technico, Copersucar No. 47: 19-23.

O' Brien, P.C. (1982). A Study on host range of *Pratylenchus thornei* Australian Pl. Pathol., 11 (1): 3-5.

O` Brien, P.C. (1983). A Further Study on host range of *Pratylenchus thornei* Australian Pl. Pathol., 12 (1): 1-3.

Orion, D. (1974). Nematodes of vegetable crops and potatoes and their control. In Scientific Activities 1971-74 of the Division of Nematology, Institute of Plant Projection, Bet Dagan Isreal.

Orion, D., Krikun, J-& Sullami, M. (1979). The Distribution, Pathogenicity and Ecology of *Pratylenchus thornei* in the Northern Negv. Phytoparasitica 7 (1): 3-9.

Orion, D., Krikun, J-& Amir, J. (1982). Population dynamics of *Pratylenchus thornei* and its effect on wheat in a semiarid region. Abstr XVIth International Symposiun of European Society of Nematologists. St. Andrews Scotland U.K,P.48.

Orion, D., Amir, J. and Krikun J. (1984) Field observation on *Pratylenchus thornei* and its effcct of wheat under arid conditions Rev. Nematol, 7 (4): 341-345.

Ofeifa, B.A. – (1962). Species of root lesion rematodes commonly associated with economic crapsin the delta of the U.AR. Pl. Dis. Reptr., 46: 572-575.

Papavizas, G.C. (1966). Prevention of Aphanomyces root rot of peas by cruciferous soil amendments. Phytopathology, 56: 1071-1075.

Papavizas G.C. (1973) Status of applied biological control of soil borne plant pathogens. Soil Biol. Biochem., 5: 709-720.

Patel, H.R.; Thakar, N.A. and Patel, C.C. Yean D. Azolla and mustard cake against nematicides for root- knot management Inokra. Madras Agri. J., 72 (10): 593-594.

Patel, P.N. and Thakar, N.A. (1989). Organic – amendments in control of the stunt nematode *Tylenchorhynchus vulgaris* 19 (1): 81-82.

Patrick, Z.A.: Sayre, R.M. and Thorpe, M.J. (1965) Nematicidal Substances selective for plant parasitic nematodes in extract of decomposing rye. Phytopathology, 55: 702-705.

Philis, J. (1976). Occurence and control of nematodes affecting carrot crops in Cyprus. Nematologia Mediterranea 4 (1); 7-12.

Prasad, J.S., Roy, Y.S. (1979). Effect of mixed cropping on the build up of the parasitic nematodes of rice. Nematological Society of India

Abstract of paper presented at the Nematology Symposium held at Bhubeneshwar, Orissa, India, March 1979. Indian J. of Nematol, 9 (1):55.

Price, N.S. (1994). Field trail evaluation of musa varieties and of other crops as hosts of *Pratylenchus goodey* in Cameroon. Afro-Asian-Journal of nematology, 4(1), 11-16 24 ref.

Quraishi, M.A. (1985). The fluctuation of population of certain plant parasitic nematodes under the Effect of fertilizers NPK in grape vine yards of Hyderabad Proc. Indian Acad. Parasitol, 6 (1/2): 89-92.

Rabeh, M.R.M. and Sweelam, M.E. (1990). Efficacy of Potassium, nematicide and their combination in relation to absorption of potassium and population of citrus nematodes *Tylenchuhus semipenetrans* and yield of Mandarin. Indian, J. Agri. Sci., 60 (1): 52-55.

Ramakrishnan, S., Vadivelu, S. 2995. Nematodes associated with chrysanthemum and their management. South Indian Horticulture, 47: 5-6, 174-175.

Recuenco, J.D. (1975) The Pathogenicity and incidence of root lesion nematode on Sugarcane. Philipine Sugar Institute Quarterly, 21; 20-24.

Rivoal, R.; Person, I; Caubel, G. and Scottola Massese, C. (1978). Methods d. evaluation dela resistance descercules au development des nematode *Ditylenchus dipsaci, Heterodera* avenae *Pratylenchus spp.* Ann. Amelior. Plantes, 28: 371-394.

Rodriguez-Kabanna, R.; King, P.S. and ingram, E.G. (1978). Urea and backstrap, Molasses for control of *Meloidogyne arenaria.* J. Nematol, 10 (4): 297-298.

Rodriguez-Kabana, R. and Collins, R.J. (1980). Relation of Fertilizer treatment and cropping sequence on population of *Pratylenchus scribneri.* Nematropica 10 (20: 121-129)

Romero M.D. and Arias, M. (1969). Nematodes de solanaceaus cultivades cu lazona mediterranea delsurde Es Pana. I. Tylenchida Bol. R. soc. Espan Hist. Nat (Biol.) 67: 121-142.

Sawazaki, E., lordello, A.L.L. and lordello, R.R.A. (1987) Inheritance of Corn resistance to *Pratylenches spp.* Bragantia, 46 (1); 27-33.

Saxena, P.K.; Chhabra, H.K. and Jasial. K. (1977). Effect of nematodes infesting grape vines. Zeites chrift fur Angewandte Zoologie. 64 (3): 325-330.

Schauer – Blume, M. (1988). Effect of extraction residues of neem seed Kernels (*Azadirachta* indica) on *Pratylenchus penetrans.* Gesunde PF lanzen, 40 (6): 229-233.

Schmidt, D.P. (1976) Relative suitability of Soyabean Cultivars to *Pratylenchus brachyurus*, J. Nematol, 8: 302.

Scholte, K. (1989) The Effect of Netted Scab *Streptomyces* spp. and *Verticillium dehliae* on growth and yield of Potato. Research, 32 (1): 65-73. 8 ref.

Sebastian, S. and Gupta, P. (1993). Pathogenicity trial and evaluation of nematicides against *Pratylenchus thornei* on chickpea (*Cicer arietinum*) in Int. symp. On Recent approaches in Integrated nematode management of agricultural crops. C.C.S. Haryana Agric. Univ. Hissar, Aug 6-7 (Abstr.) : 74.

Sebastian, S. Gupta P. (1996) Evaluation of some Oil cakes against *Pratylenchus thornei* on chickpea. International chickpea and Pigeonpea News Letter. No. 3, 40-41 ref.

Sen. K., and Das Gupta, M.K. (1989) Control of root - knot nematode *Meloidogyne* spp. with organic amendments and soil nematicides on some successive crop. Horticultural Journal, 2 (1): 48-54.

Sethi, C.L. and Swarup G. (1971). Indian Phyto Pathology. 54: 410-412.

Shannon, J.G., Baldwin, C.H. Jr.; colliver, G.W. and Hartiwig, E.E. (1977) Potash Fertilization help fight Soyabean Cyst nematode. Better Crops with plant food, 6 (1): 12-15.

Sharma, N.K. and Sethi, C.L. 1975. Effect of initial inoculum levels of *Meloidogyne incognita* and *Heterodera cajani* on cowpea and on their population development. Indian J. Nenatol. 5: 148-154.

Sharma, S.B., Saka, V.w. and Nene, Y.L. (1984). Plant Parasitic nematodes in ICRISAT chickpea fields. Int. Chickpea Newsl. 10: 18-19.

Sharma, S.B.; Medonold, D. (1990). Global status of nematode problems of groundnut, Pigeonpea, chickpea, sorghum and pearl millet and suggestions for future work. Crop Prot., 9: 453-458.

Sharma, S.B. Smitt. D.H. and Medonald, D. (1992). Nematode constraints of chickpea and Pigeonpea production in the Semi – arid tropics. Plant Disease 76 (9): 864:868.

Sher, S.A. and Allen, M.W. (1953). Revision of the genus *Pratylenchus* (Nematoda – Tylenchida). Univ. Calif. Pub Zool, 57 (6): 441-470.

Shukla, P.K., Haseeb, A. (1996). Effectiveness of some nematicides and oil cakes in the management of *Pratylenchus thornei* on *Menthcitrata*, *M. piperita* and *M. spicata*. Bio-resource Technology – 57 (3) : 307-310, 14 ref.

Siddiqui, Z.A.; Khan, A.M. and Khan, M.W. 1976. Control of *Tylenchrohynchus brassicae* by the application of oil cake. Indian J. Nematol, 6: 145-149.

Siddiqui, Z.A.; Khan, M.W. and Khan, A.M. (1976). Nematode population and yield of certain vegetables as influenced by oil cake amendments. Indian, J. Nematol, 6 (2): 179-180.

Singh, S.K., Khan. M.R. and Khan, A.A. (1988) Effect of organic soil amendments on rhizosphere fungi and root knot nematode on egg. plant. Indian J. Applied and Pure Biology, 3 (2) : 103-106.

Sitaramaih, K. and Singh, R.S. (1978). Effect of organic amendments on Phenolic content of soil and plant and response of *Melodogyne javanica* and its host to related compounds. Plant & Soil, 50 (3): 672.

Smil Jkovic, H.; Martinovic, M. and Grujcic, G. (1974). Uticaj Fitopatogenih nematoda na Pojavu trulezi Kukeruza, Biljna, Zast, 25: 153-158.

Smith, O.D. Boswell, T.E. and Thames, W.H. 1978, Lesion nematodes resistance in Peanuts, Crop. Sci. 18: 1008-11.

Sobin, N.; Nema, K.G. and Dave, G.S. (1979). Possible interrelationship between plant parasitic nematode *Tylenchorlynchus* and a root rot fungus from gram (*Cicer arietinum* L). In "Physiology of Parasitism", eds. Agarwal, G.P. and Bilgrami, K.S. Current Trends in Life Sciences. Today and Tomorrow wis Printers and Publisher, New Delhi, 7: 451-456.

Storey, R.M.J., Glazer, I and orion, D. (1982). Lipid Utilization by starved and anhydrobiotic individuals of *Pratylenchus thornei*: Nematologica, 28 (4) : 373-378.

Sundararaju, P. and Koshy. P.K. (1986). Effect of different nematodes and neem oil cakes in the control of *Radopholus similis* in yellow leaf disease affected arecanut palm. J. Nematol, 16 (1): 44-47.

Supratoyo (1993) Studies on the effect of *Tagetes erecta* and *Tagetes patua* for controlling plant parasitic nematodes on banana. Iimu-Pertanian, 5:3, 681-691. 6 ref.

Tacconi, R.; Giordani, G. and Toderi, G. (1988). Effect of fertilization and rotation on population of *Pratylenchus thornei.* Infornatore Fitopato logico. 38 (1): 47-50.

Tarte, R. (1971). The relationship between pre – plant populations of *Pratylenchus zeae* and growth and yield of Corn. J. Nematol, 3: 330-331.

Thomason, I.J.; Rich, J.R. and O' Melia, F.C. (1976) Pathology and histopathology of *Pratylenchus sribneri* infecting Snap bean and Limbean. J. Nematol. 8: 347-352.

Thompson, J.P. (1990). Treatments to eliminate root lesion namatode (*Pratylenchus thornei* Sher and Allen) from a vertisol. Nematologia. 36 1): 123-127, 15 ref.

Thompson, J.P., Mackenzie, J., Amos, R. (1995). Australian – J. of Experimental. Agriculture. 35 (7). 1049-1055. 12 ref.

Townshed, J.L. (1990). Methods of evaluating resistance to lesion nematodes *Pratylenchus* species. In "Methods for Evaluating Plant Species for Resistance to Plant Parasitic Nematodes". Beltsville, Maryland U.S.A., Society of Nematologists: 33- 41.

Tyagi, S.A. and Parveen, M. (1992). Pathogenic effect of root lesion nematode, *Pratylenchus thornei* on plant growth, water absorption

capacity and chlorophyll content of chickpea. Int. chickpea Newsl., 26: 18-20.

Updhayay, R.S. Khan, A.M. and Saxena, S.K. (1974). Effect of certain inorganic fertilizers on survival of nematodes in the absence of host (Abstract No. 68). In Proceeding of the 61st Indian Science Congress, Nagpur, Part – III C.

Van Gundy, S.D., Perez, B.J.G.; Stolay, L.H. and Thomason, I.J. (1974). A pest management approach to the control of *Pratylenchus thornei.*

Vito, M.D.I.; Greco, N. and Acheo, G. (1987). Nematode problems in the cultivation of chickpea. Terrae sole, No. 534: 112-113.

Vito-m-di, Greco, N. and Di-Vito-M. (1994). Control of food legume nematodes in the Mediterraneah Barin. Bulle OEPP, 24 (20: 589- 494). Zoref.

Vovlas, N. and Inserra, R. N. (1977). Histological alterations induced by *Pratylenchus* and *Zygotylenchus guevarai,* in the roots of bean. Italia Agroicola, 9: 122-125.

Walia, R.K. (1982). Studies on the root lesion nematodes *Pratylenchus spp.* infesting some pulse crops, Ph. D. Thesis, I.A.R.I. New Delhi.

Walia, R. K. and Seshadri, A.R. (1985). Pathogenicity of the root lesion nematode *Pratylenchus thornei* on chickpea. Intl. Chickpea, Newsl. 12, 31.

Walia, R.K. and Seshadri, A.R. (1985). Chemical control of *Pratylenchus thornei* on chickpea through seed treatment. Intl. Chickpea Newsl., 13: 32-34.

Walia, R.K. (1986). The rood lesion nematode *Pratylenchus.* In-"Plant Parasitic Nematodes of India: Problems and Progress". (Eds. Swarup. G. and Dasgupta, D.R.) : 211-222.

Willis, C.B.; Kimpinski, J. and Thompson, L.S. (1982). Reproduction of *Pratylenchus crenatus* and *P. penetrans* on forage legumes and grasses and effect on forage yield. Canadian J.Pl. Pathol, 4 (20:169-174).

Winfield, A.L. (1974). Observation on the occurrence, pathogenicity and control of *Pratylenchus vulnus, Pratylenchus thornei* and *Xiphinema diversicaudatum* associated with galss house roses. Ann. Appl. Bio. 77 : 297-307.

Zaiyd, M. (1977). Effect of organic soil amendments on the incidence of root knot nematode *Meloidogyne javanica* on bhindi plants. Proc. Bihar Agri. Sci., 25 (1): 23-26.